Texas Department of Transportation

Intelligent Transportation Systems (ITS)
Deployment Strategy

prepared as a part of
Research Study 0-1467
Highway Operations Research and Implementation

Sponsored by the
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

May 1996

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

TEXAS DEPARTMENT OF TRANSPORTATION
INTELLIGENT TRANSPORTATION SYSTEMS DEPLOYMENT STRATEGY

by

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TEXAS TRANSPORTATION COMMISSION

VARIOUS County **MINUTE ORDER** Page 1 of 2 Pages

District VARIOUS

WHEREAS, the Texas Department of Transportation (the "department") is committed to improving the safety and maximizing the operational efficiency of the state's surface transportation system through the development and application of Intelligent Transportation Systems (ITS) technologies; and

WHEREAS, the implementation of ITS has the potential to reduce mobile source emissions and energy consumption, thereby improving air quality; and

WHEREAS, traffic management systems are the foundation for ITS, and the department has installed a number of traffic management systems, primarily through construction contracts; and

WHEREAS, the estimated value for the operational traffic management systems and projects currently under construction is approximately $220 million; and

WHEREAS, the department has identified the need for additional ITS projects in metropolitan and urban areas of the state that, if implemented, would cost approximately $400 million over the next five years; and

WHEREAS, in addition, the estimated cost of needed rural area ITS infrastructure exceeds $200 million; and

WHEREAS, given current and potential investments, there is a need for a focused direction for ITS in the department; and

WHEREAS, recognizing this need, with the oversight of the department's ITS Committee, staff has developed the Texas Department of Transportation ITS Deployment Strategy (the "Strategy"), an executive summary of which is attached as Exhibit A, that outlines the guiding principles, deployment priorities, department roles, typical component costs, and estimated benefits of ITS for the department; and

WHEREAS, the Strategy is a product of internal and external review, comments having been received from practitioners within the department, research universities, the private sector, and through public forums held in various parts of the state; and

WHEREAS, the Strategy links with the United States Department of Transportation's (the "US DOT") Intelligent Transportation Infrastructure initiative (Operation TimeSaver) which encourages the development of a complete ITS infrastructure in the 75 largest metropolitan areas in the nation within the next 10 years; and

WHEREAS, because information and data sharing is at the core of ITS, the department recognizes the establishment of future public-private partnerships as essential to identify and share resources, such as technical expertise and technology; and

WHEREAS, statewide operational consistency is necessary in order to realize the maximum benefit of the technology and to provide the greatest degree of ITS user acceptance; and

WHEREAS, a uniformity in design of ITS is in the best interest of the department for reasons of systems compatibility across the state, interoperability, ease of maintenance, interchangeable components, and contractor/vendor familiarity with project specifications; and

WHEREAS, the desirability of ITS standards is indicated by the national effort fostered by the US DOT to develop a national ITS architecture that defines relationships among ITS components; and

WHEREAS, further efforts by existing national standard-setting organizations to create specific standards, guided by the national architecture, are being funded by the US DOT; and

TEXAS TRANSPORTATION COMMISSION

VARIOUS County **MINUTE ORDER**

District VARIOUS

WHEREAS, the actions ordered herein are consistent with Policy 4 (Utilize Technology to Increase Transportation Mobility) and Strategy 4.1 (Develop and Encourage Widespread and Cost Effective Applications of ITS Technology) of the Texas Transportation Plan;

NOW, THEREFORE, IT IS ORDERED that the Texas Transportation Commission affirms the commitment of the department to ITS deployment and supports the continuance of this role in providing innovative transportation solutions; and

IT IS FURTHER ORDERED that the executive director is to determine the appropriate level of financial commitment necessary to support an aggressive ITS deployment effort (including maintenance and operations of the systems deployed), and that ITS be integrated, when appropriate, into department operations; and

IT IS FURTHER ORDERED that the department will coordinate with all transportation partners in the deployment of an ITS infrastructure that is operationally seamless between jurisdictions and between transportation modes; and

IT IS FURTHER ORDERED that the department is hereby directed to pursue, in conjunction with national activities, the development, implementation and maintenance of standards and specifications that define any ITS deployed by the department.

Submitted by:

David B. Newlin

Director, Traffic Operations Division

Reviewed by:

~~Assistant~~ Executive Director for Multimodal Transportation

Recommended by:

Executive Director

Minute Number 106826

Date Passed MAY 30 96

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INTRODUCTION

The purpose of this document is to present an initial TxDOT-wide framework for the deployment of Intelligent Transportation Systems (ITS) technologies, techniques and practices in support of the principal agency mission of moving people and goods efficiently and effectively. This "strategy" is *not* intended to be a prescription for every community, or even one community. Rather, it attempts to identify the key ingredients for successful ITS deployment. The recipe for any community or agency should be based on identified needs and available resources. This strategy focuses on deployment in the "near-term," meaning the next five years.

GUIDING PRINCIPLES

An effective deployment strategy must be built on underlying principles that are not affected by rapid technological change because needs, technology and associated applications can change rapidly.

Action orientation -- Rapid deployment of building block ITS projects should be promoted, while long-term planning for large scale projects is under way. Staged deployment of systems and subsystems provides near term benefits to the public, allows some flexibility to incorporate evolving technologies, and is more easily adaptable to changing budgetary climates.

Satisfy a public need -- To meet the requirements of this guiding principle, the ITS project/program designer must be able to describe clearly what public need is being satisfied, rather than falling victim to the glamour of technology.

Optimize partnerships -- Because ITS is information based, virtually all projects and partners in numerous agencies and jurisdictions can benefit from shared information. Information sharing reduces redundancies and discrepancies, takes advantage of economies of scale, and improves service to the ultimate customer. Surface transportation systems are interdependent; this shared "intelligence" is the missing link that enables true multimodal and intermodal operation.

Minimize long term costs -- Ideally, the ITS project: a) balances near-term priorities with long-term operating costs (an agency isn't stuck with a system that is cheap to purchase and install, but too expensive to operate and maintain; or one that does not do the job and is therefore ineffective), b) maximizes investment, including use of existing facilities, and c) maximizes opportunities to incorporate ITS elements into other projects.

Deploy strategically -- ITS projects should logically fit into the overall local ITS planning, as well as the broader transportation plans by: a) maximizing compatibility with existing systems (i.e., don't start over), b) using a "building block" approach to support future or expanded deployment, and c) incorporating technology that is flexible, compatible and expandable.

Keep "locals" in the driver's seat -- Although TxDOT can promulgate standards and expectations statewide, ultimate deployment success is local and can only be achieved by commitment to local action and continuing coordination. Local-level deployment fosters consistency with other local efforts, reflects community desires, and recognizes that viable planning must optimize the local factors of need, resources, vision, and commitment.

DEPLOYMENT PRIORITIES

A multifaceted approach, incorporating "hands-on"experience, and research and national expertise, was used to develop the recommended deployment priorities shown in Table 1. Using the **Texas Transportation Plan** as policy guidance, an internal TxDOT team composed of mid-to-senior level practitioners provided overall direction for the development of the strategy.

Recommended Emphasis Areas -- *TxDOT-led activities*

Some actions TxDOT can take unilaterally because the facilities and functions involved are solely the responsibility of TxDOT.

Traffic control -- TxDOT should continue the active role in deployment on state roads, both urban and rural, and should initiate dialogue with other entities to promote effective operation between contiguous systems (such as freeway-arterial interfaces). All interested parties should avoid the tendency to see this and other ITS services primarily as urban tools. For example, the ability to remotely monitor and control hurricane evacuation routes along the coast is a form of traffic control.

En-route driver information -- Though changeable message signs alongside an urban freeway are the stereotypical image of this service, it spans a wide range of applications. In many parts of Texas, the need to inform the traveling public of unexpected safety risks, such as impending flash floods or icing of bridges, can be as important and potentially more urgent than managing daily freeway congestion. This service area may offer future opportunities for private sector participation. TxDOT should begin examining policies that facilitate private sector involvement while protecting public responsibilities.

Incident management -- TxDOT can play a major leadership role in incident management, especially in the deployment of technology on state roads, but effective response to incidents can only be achieved through local cooperation and coordination. TxDOT should facilitate the dialogue needed to achieve a local consensus about the purpose, value, and roles in incident management.

Rail-highway grade crossings -- This area could be among the first to reflect true public-private partnership. Data sharing, especially regarding the streamlining of information and warning at grade crossings has significant safety potential. Furthermore, the railroad industry has been practicing many of the forms of automated control for many years and may be able to share transferable experience with TxDOT and other public entities.

Table 1. Recommended Early Emphasis Areas

User Service	TxDOT Near-Term Role	Deployment Roles[1]			
		TxDOT	City/ County	Transit Authority	Private
Traffic Control	Deployment (State roads)	◆	❖	❍	
En-Route Driver Information	Deployment (also facilitate long-term private role)	◆	❖	❍	Info Providers?
Incident Management	Leadership of local partners + Deployment (State roads)	◆	❖	❖	Cellular Providers?
Rail-Highway Grade Crossing Operations	Exploration + Deployment	◆			Railroads
Smart Emergency Systems	Coordination + Deployment	❍	◆		
Pre-trip Travel Information	Leadership (establish policy framework for private sector delivery)+ Coordination	❖	◆	◆	Info Providers?
Travel Demand Management	Coordination w/ local entities	❍	◆	◆	
Public Transportation Management	Coordination w/ transit authorities	❍	❍	◆	
En-Route Transit Information	Provide access to real-time system condition data	❍	❍	◆	
Public Travel Security	Coordination of video capabilities w/ transit authorities	❍	❍	◆	
Commercial Vehicle Electronic Clearance	Coordination w/ federal, state and motor carriers	❖	❍		◆ - Motor Carriers
Commercial Vehicle Administrative Processes	Coordination w/ motor carriers	❖	❍		◆ - Motor Carriers

[1]◆ = Typical Lead Role; ❖ = Alternate Lead Role; ❍ = Typical Support Role

Recommended Emphasis Areas -- *Public agency partnerships*
Several services can be provided to the public via partnerships between TxDOT and other public entities, usually cities, counties, or transit agencies that would be responsible for some aspect of deployment, such as capital funding or construction, or support for continuing maintenance and operation.

Smart Emergency Systems -- These systems provide substantially improved emergency response by making real-time route status information, such as blocked railroad grade crossings and construction-related lane closures, available to emergency dispatchers, who can then choose the most appropriate vehicle and route to minimize response time. Other systems allow the emergency vehicle to communicate directly with traffic signals, giving them the green light, reducing response time, and improving safety.

Pre-trip travel information -- In many respects, pre-trip traveler information is a mechanism for voluntary travel demand management. This service is envisioned as a market opportunity for private sector "information service providers." TxDOT should begin examining a policy framework that would allow appropriate access and involvement by private sector entities.

Travel demand management -- More aggressive travel demand management is a matter of metropolitan area public policy and requires mutually supportive efforts by all pertinent entities. TxDOT should coordinate with local entities to identify those efforts that can be supported by ITS technologies.

Public transportation management -- Partnership with transit entities, particularly metropolitan transit authorities, offer great potential to broaden the service base for little or no additional investment by TxDOT. Many of the transit services, including *en-route transit information*, are dependent on either the real-time traffic condition database derived from the basic services, or on the communications network deployed by TxDOT for the provision of other services. Other cooperative efforts can make use of shared video links to improve surveillance and *traveler security* at transit centers and bus stops.

Recommended Emphasis Areas -- *Private sector participation*
Private sector involvement in ITS is a significant departure from the historic relationship with most public entities, usually involving the providing of a public-oriented service in exchange for a market opportunity.

Commercial vehicle electronic clearance -- This service could significantly improve the speed and efficiency of weighing and clearing vehicles, especially those originating across the border.

Commercial vehicle administrative processes -- Developed in combination with the previous service, this one could significantly benefit the trucking industry.

TXDOT ROLE

TxDOT's role in ITS deployment will vary from unilateral deployment to facilitator, depending on the local need. This strategy emphasizes the importance of flexibility in each community, allowing the entities with the needs and resources to take on leadership roles, even in activities typically led by TxDOT. For example, if a transit authority has the needs and resources to aggressively lead the incident management effort, then TxDOT should encourage that and maintain a supportive role.

For the most part, TxDOT's role in deployment will be to adopt a broad view of "needs" when planning TxDOT deployments, thereby capturing opportunities to accomplish the goals of multiple entities at little or no additional cost to TxDOT. Some examples of that notion follow.

Communications infrastructure -- In most metropolitan areas, TxDOT will have significant deployment of ITS applications along roadways on the State system. In developing communication plans for linking these applications, TxDOT should consider potential future partners from other areas, such as public sector agencies and the sought-after private sector, and design open and flexible systems with future partners in mind.

Planning and coordination -- The Metropolitan Planning Organization (MPO) could be the vehicle for initiating or resuming the interagency communication necessary for successful local deployment of ITS. It will be important for all task groups to include appropriate management expertise to ensure that focus on problem solving is maintained, rather than a focus on technology.

Funding -- TxDOT should aggressively pursue deployment funding for purposes of unilateral implementation on State routes, and for TxDOT's share of public and/or private partnerships. In order to make maximum effective use of scarce funds, it is recommended that TxDOT not attempt to provide funding for a local entity's share of a joint project.

Maintenance and operations -- As the strength of ITS is in broad deployment and sustained operations, an implementation decision should consider long term maintenance and operations costs, as well as personnel and training implications. The importance of this commitment is emphasized by the building block nature of anticipated deployment packages, meaning that the previous block needs to be functioning adequately to accomplish the purposes of successive deployments. Further, TxDOT must be able to attract and retain the personnel needed to gain maximum benefit from deployed technology.

TxDOT Internal Roles

Districts -- As recognized in major national efforts, ITS is very locally-focused, meaning that the districts are going to be the key organizational elements in ITS deployment. The district staff should be actively participating at the local level to facilitate this strategy.

Divisions -- The role of the divisions is a variation on the current role.

- **Statewide integration of projects** — insuring compatibility, consistency, and continued development of departmental learning.

- **Statewide Standard setting** — consistent with national standards and related TxDOT standards.
- **Statewide Clearinghouse for information and expertise** — serve as resource, both internally and externally, especially current sources of expertise throughout the state.

COSTS AND BENEFITS

Determining whether an ITS project is the most cost-effective approach to a public need requires analysis of the potential costs and benefits. Though the field is relatively new, the data upon which to base such decisions is growing. In assessing the benefit/cost relationship of an ITS project, the decision makers should also consider a comparative benefit/cost analysis of any other approach to meeting the targeted public need.

Costs of ITS Deployment -- The Federal Highway Administration has compiled some "typical" urban area estimates for the full-scale deployment of "core infrastructure" throughout the urban area. Table 2 summarizes variable costs estimated for the major categories; lump sum cost estimates for the remaining categories are shown in Table 3. *Understanding the underlying assumptions (contained in the full "Strategy" document) is crucial to accurate interpretation; it should be noted that early efforts (near-term) will include only a fraction of an urban area, at a fraction of the costs shown.* In round numbers, the capital cost of deployment of the infrastructure will about $400,000 per freeway mile plus $3,000 per signalized intersection. Operations and maintenance of the Intelligent Transportation Infrastructure will run 5-8 percent of the capital cost.

Benefits of ITS Deployment -- Because hard before-and-after data is still being compiled nationally, most benefits are still estimated in ranges. Table 4, developed by the U.S. Department of Transportation, shows *illustrative* estimates of benefits observed from projects around the country. To assure deployments are cost-effective, an analysis of expected benefits should be required prior to the commitment of funds. A database of actual benefits should be developed and maintained to assure continued improvement in the ability to justify projects.

INTERNAL POLICY ISSUES

It is recommended that TxDOT examine and establish internal policies for the following issues central to the effective deployment of ITS.

Private sector participation -- Because the private sector role is evolving, public policy must also evolve to take advantage of it. Not only may public agency procurement procedures need to be modified, but resource allocation funding, R&D, planning, design, deployment, and operational procedures may also need to be adjusted to be able to form long-lasting, working partnerships with the private sector.

Table 2. Gross Estimates of Variable Core Infrastructure Costs[2]					
Function	**ITS Element**	**Cost per Freeway Mile**		**Cost per Arterial Intersection**	
		Capital Cost	Annual O&M Cost	Capital Cost	Annual O&M Cost
Surveillance	Closed Circuit TV	$20,000	$1,000	$2,000	$1,000
	Loops	$10,000	$640	$8,000	$480
	Video			$4,000	$200
Traveler Information	Changeable Message Signs	$50,000	$2,500	$1,000	$40
	Ramp Meters	$40,000	$2,000		
	Signal Upgrades			$5,000	$250
Communication	Call Boxes	$20,000			
	Fiber Optics	$240,000	$12,000		
	Signal Communications			$10,000	$500
TOTALS		$380,000	$20,000	$30,000	$2,500

Table 3. Gross Estimates of Lump Sum Core Infrastructure Costs[1]						
ELEMENTS	**Large City**		**Medium City**		**Small City**	
	O&M Cost ($000's)	Capital Cost ($000's)	O&M Cost ($000's)	Capital Cost ($000's)	O&M Cost ($000's)	Capital Cost ($000's)
Transportation Management Centers	12,270	29,400	6,306	15,724	925	3,496
Traveler Information Center	3,720	10,402	2,929	8,082	1,159	4,671
Transit Management Center	372	4,430	278	3,652	206	3,128
Emergency Management Centers	370	4,400	277	3,532	205	3,098
Transit Vehicle Interfaces	630	12,600	378	7,560	32	630
Emergency Vehicle Services	50	990	38	750	8	150
Incident Management Equipment	2,295	8,675	2,460	3,325	0	0
System Design & Integration	0	5,400	0	4,320	0	3,780
Electronic Toll Collection Systems	7,310	8,675	2,460	3,325	0	0
Electronic Fare Payment System	4,366	103,320	2,657	62,732	0	0

[2]Assumes full city-wide deployment and other significant assumptions; see full report for details.

Funding of capital improvements and O&M -- TxDOT should continue to refine the estimated capital costs of deployment. Further, TxDOT should adopt a policy that assures adequate funding for maintenance and operation of any ITS system deployed.

Development of ITS and related standards -- TxDOT should identify those areas of ITS and related technologies, such as geographic information systems, that require or warrant statewide standards and, consistent with national ITS planning, develop appropriate standards for Texas. These standards will benefit TxDOT and local governments that want to develop compatible systems of their own.

Achieving "seamless integration" across jurisdictional lines -- Because the roadway network functions that way, the traveling public should be able to take advantage of intelligent systems without hindrance of jurisdictional boundaries. TxDOT needs to develop a strategy for making its deployments "seamless" or "transparent." One source has noted that " . . . the interconnection of institutions is a prerequisite to the interconnection of parts."

Table 4. Typical Benefits[2] -- Intelligent Transportation Infrastructure

Freeway Management Systems. A formal program for improving traffic flow on high-volume roadway segments via adjustments to ramp metering rates, variable message signs, and highway advisory radio messages based on real-time traffic surveillance. Ramp metering in Minneapolis, MN increased freeway speeds by 35 percent and freeway capacity by 22 percent and reduced accident rates by 31 percent.				
Operations Improvement	**Safety Improvement**	**Environmental Improvement**		
Travel Time - 20 - 48 % Travel Speed - 16 - 62 % Freeway Capacity - 17 - 25 %	Accident Rate - 15 - 50 %	CO - 122,000 tons yearly	HC - 1400 tons yearly	NOx - 1200 tons yearly
		Fuel Consumption 41 %		
Traffic Signal Systems Benefits. Optimize traffic flow by adjusting signal timing and patterns in response to real-time traffic data. Coordinated, computerized traffic signals in Lexington, KY reduced stop-and-go traffic delays by about 40% and reduced accidents by 31 percent.				
Operations Improvement		**Environmental Improvement**		
Travel Time - 8 - 15 % Travel Speed - 14 - 22 % Vehicle Stops - 0 - 35 % Delay - 17 - 37 %		CO - 5 - 13 %	HC - 4 - 10 %	
		Fuel Consumption 6 - 12 %		

[2]Source: U.S. Department of Transportation

Table 4. Typical Benefits[3] -- (con't.)

Incident Management Program Benefits. A program to identify and respond to vehicle accidents and breakdowns with appropriate emergency services and restore roadway to full service. The incident management program in Chicago, IL has reduced the time to clear incidents by 50 percent.	
Operations Improvement	**Safety Improvement**
Travel Time - 10 - 42 % Incident Clearance Time - 8 minutes for stalls 5 -7 minutes for wrecker response	Fatalities - 10 %

Traveler Information System Benefits. Collect, analyze, and distribute accurate, reliable, and timely travel information to travelers and commercial carriers when and where they want it. Montgomery County, MD broadcasts traffic conditions on major roadways to 180,000 homes via cable television.			
Operations Improvement	**Environmental Improvement**		
Travel Time - 20 % in incident conditions, 8 - 20 % for equipped vehicles Delay - 1900 vehicle hours/incident	VOC - 25 %	HC - 33 %	NOx - 1.5 %
	Fuel Consumption - 6 - 12 %		

Transit Management System Benefits. A program for managing bus operations based on real-time bus location information. Using automatic vehicle location (AVL) data to optimize bus routes and reduce run times allowed Kansas City, MO to eliminate seven buses from its fleet of 200. The savings paid for the system in two years.	
Operations Improvement	
Travel Time - 15-18% Security - response time 1 minute	Service Reliability - 12-23% Cost Effectiveness - 45% annual return on investment

Electronic Toll Collection System Benefits. A system to allow nonstop toll payment. The Oklahoma Turnpike's electronic toll collection system minimizes driver delays and has cut the State's operational cost per lane for toll collection by 91 percent.			
Operations Improvement	**Environmental Improvement**		
Operating Expenses - 90 % Capacity - 250 %	CO - 72 %	HC - 83 %	NO_x - 45 %
	Fuel Consumption - 6 - 12 %		

Electronic Fare Payment System Benefits. A system to consolidate all transit and parking transactions onto one card to add convenience for users and provide centralized information to transit agency managers. In Los Angeles, CA the benefits of Smart Cards were shown to exceed the cost by more than double.			
Operations Improvement	**Environmental Improvement**		
Patron Popularity - 90 % usage Fare Collection - 3 - 30 % Data Collection Costs - $ 1.5 - 5M less	CO - 72%	HC - 83%	NO_x - 45%
	Fuel Consumption - 6-12%		

[3]Source: U.S. Department of Transportation

CHAPTER ONE

INTRODUCTION

TEXAS DEPARTMENT OF TRANSPORTATION
INTELLIGENT TRANSPORTATION SYSTEMS (ITS)
DEPLOYMENT STRATEGY

Once upon a time the Information Age descended on Transportation, bringing excitement and hope compounded by confusion and trepidation. An industry that had often lagged a generation or more behind in technology suddenly became a frontier. Those pioneers who had dutifully managed the delivery of transportation services to a nation found themselves besieged with new "tools," new "opportunities," and a compelling need to modify their long-standing paradigm of mobility. And yet the same public that demands innovation also demands stewardship and abhors wastefulness. So the pioneers were faced with making sense out of all the "opportunities," and bringing about some kind of orderly transition into a newer and ever-changing manner of providing mobility to the public.

The pioneers wisely said to themselves, "Since we can't do everything at once, what should we do first?" As they began to sort through the myriad of modes and strategies and technologies, they began to find rational ways to set priorities. As the sorting process continued, they began to recognize at least two fundamental truisms about this new frontier: a) that there were many questions that remained unanswered, and b) that the process of sorting, prioritizing and strategizing would need to be continued.

INTRODUCTION

This *ITS Deployment Strategy* documents the TxDOT efforts to date in three key areas identified by the pioneers:

- a set of near-term priorities for TxDOT is identified,
- an initial set of key policy questions is developed and the drafting of those policies is underway, and
- the stage is set for the development of more detailed assistance and direction in follow-on activities.

Purpose

The purpose of this document is to present an initial TxDOT-wide framework for the deployment of ITS technologies, techniques, and practices in support of the principal agency mission of moving people and goods efficiently and effectively. This deployment strategy is a guide for the efforts of TxDOT headquarters and district personnel in the development of programs and projects that fall under the ITS umbrella. By taking this broad, integrated approach, TxDOT can deploy ITS elements faster and more productively, while retaining the flexibility needed to meet local or situation-driven needs.

This "strategy" is *not* intended to be a prescription for every community, or even one community. It attempts to identify the key *ingredients* to successful ITS deployment. The *recipe* for any community of agency should be based on identified needs and available resources.

Scope

The focus of this strategy is on deployment of ITS. While many of the actions emanating from this strategy will be within the direct purview of TxDOT, some actions will be implemented by other jurisdictions or the private sector. In all cases, an effort will be made to identify the proper role for TxDOT, whether it is implementation, support, promotion, or awareness.

Some mistakenly view ITS deployment as mainly freeway traffic management from traffic management centers. ITS is much more than traffic management, and much more than traffic management centers. There are very real deployment applications possible, and some are under way in rural areas, motor carrier operations, and intermodal operations here in Texas.

In the simplest form, ITS is data and information sharing. Much of the basic effort should focus on placing the *right information* in the *right hands* at the *right time*. Whether the person involved is a traveler, a vehicle operator or a TxDOT staff member devising operational plans, having accurate, timely information allows them the opportunity to make effective decisions regarding the use of the transportation network.

Document Structure

This Deployment Strategy includes the following sections:

- Chapter Two, Guiding Principles -- representing the basic philosophical and policy position of TxDOT regarding the deployment of ITS applications.
- Chapter Three, Deployment Priorities -- those ITS elements that will be the TxDOT focus over the near term, defined as the next five years.
- Chapter Four, Roles and Responsibilities -- principally the role that TxDOT will play in deployment, planning, funding, and maintenance and operations.
- Chapter Five, Costs and Benefits of ITS -- "rules of thumb" for cost estimates and summaries of expected benefits.
- Chapter Six, Next Steps -- where does this "Deployment Strategy" lead?

- Appendices:
  - A — Project Evaluation Guidelines -- factors to consider in rating projects
  - B — Detailed Deployment Scenarios and TxDOT Role by User Service
  - C — Core Infrastructure -- FHWA White Paper on deployment priorities
  - D — Definitions of User Services
  - E — Cost Estimate and Assumptions for the Core Infrastructure

CONTEXT FOR ITS DEPLOYMENT PLANNING

TxDOT has been deploying elements of ITS for more than 30 years. In the largest sense, the surveillance and control systems of the 1960s on the Gulf Freeway in Houston and the North Central Expressway in Dallas were pioneering efforts in the use of technology to improve transportation. More common, but no less significant, efforts include responsive traffic signal systems on city streets and State roads across Texas. While the possibilities are much broader under the "new" ITS emphasis, TxDOT must take advantage of the investment and rich heritage of the recent past to make the most of the future.

Where We Have Been

Texans and TxDOT have been advancing the application of technology to transportation systems since the 1960s. Incident detection schemes, motorist information systems and diversion strategies, freeway flow models, ramp metering applications, and guidelines for video surveillance are the result of initiatives in Texas. Other projects have developed the PASSER and TEXAS signal timing programs and the TRASER accident analysis system. These and many other efforts originated in Texas and have been applied throughout the nation.

The commitment to effective traffic management has not been solely dependent on continued advancement in technology. Transportation professionals in cities, counties, and districts have continued to address local needs with all the tools at their disposal. The evolution of those tools and the ability to make them work together better is one of the principal benefits of ITS.

One of the most common questions about ITS deployment is: "Where do we start?" The answer is: "wherever you are now, not from the beginning." To be cost-effective, ITS deployment continues building on existing systems, policies, and successes. Agencies that have a significant investment in transportation management should build from there toward a future vision. Even if plans conceived a decade or more ago are not precisely desirable today, they represent investment and progress, and should not be scrapped. Furthermore, any plans developed now must be sufficiently flexible to respond to change as new technologies open new opportunities.

The key to continued success will be to work toward a vision. That vision will need to be regularly reaffirmed and occasionally adjusted. Plans to reach that vision will also need to be adjusted as the vision becomes clearer.

Current Activities In Texas

There are ITS deployment projects underway literally all over Texas. An internal TxDOT status report includes all projects where TxDOT is a participant (*1*). The most recent update of that report will provide the reader with a sense of the magnitude of work under way:

- There are Early Deployment Planning projects underway in Austin, Dallas, El Paso, Ft. Worth, San Antonio and along the I-10 corridor from San Antonio to New Orleans. The three million dollar budget for these projects'planning efforts represents a coalition of federal, TxDOT and local funds. These projects address a wide range of ITS planning, from area-wide plans to management of truck congestion at international bridges.

- The Houston ITS Priority Corridor is one of the ISTEA federal demonstration projects. More than nine million dollars of federal, state and local funds has been allocated to numerous different but integrated efforts. To date 14 different projects are authorized for study and planning. The Houston Priority Corridor Program has identified $34 million in additional project needs.

- The largest and most visible efforts are the Transportation Management Centers in San Antonio and Houston. San Antonio's TransGuide Center is operational, and has more than 25 miles of freeway currently under surveillance and control, with expansion ongoing to an ultimate 191 miles. Houston is fully operational with the opening of the TranStar Center in April 1996. Houston will eventually have more than 300 miles of freeway and HOV lanes under surveillance and control.

- Operational ITS projects are not limited to major metropolitan areas. Several smaller districts have already deployed closed loop traffic signal systems. These systems, more dynamically responsive to changing travel patterns than other systems to date, are used in Corpus Christi, Lufkin, Pharr and Tyler, and are in various planning stages in other communities. Other ITS applications in place in non-metro areas include remote sensing of bridge icing in Amarillo, wireless interconnect of a signal system in Childress, and remote control of signal systems near the border bridges in Laredo.

- Finally, freeway traffic management systems are in place or pending in Dallas, El Paso, Ft. Worth, Houston and San Antonio. These systems operate and/or coordinate operations between freeways, arterials, and HOV lanes. From the traveling public's perspective, these systems provide responsive signal systems, changeable message signs, lane control, and ramp metering. From the public agencies' point of view, these systems provide significant mobility improvements at a fraction of the cost of widening a freeway or arterial street.

Where We Are Going

As ITS develops to its full potential, a number of new services will be possible for the traveling public. As the traveler departs on vacation, complete information on the best alternative routes based on traffic conditions, weather conditions, construction, maintenance work, special events, or any other activity that could positively or negatively affect the enjoyment of the trip will be available. To make this vision possible, a repackaging of many information databases that are currently designed for narrowly focused purposes will be required. Underlying these new databases will be a geographic information system. This geographic information system is essential to be able to relate this information in time and space. Without such a system, it would be difficult to interrelate these various information sources.

As various databases are integrated together, improvements will result in the quality of data and types of data available. For example, planners will have access to traffic data in a timely fashion without the need of personnel to collect it because it will be provided from existing traffic control systems. Likewise, the availability of geographic information systems will help maintenance supervisors identify the location of potholes and automatically issue work orders. A maintenance supervisor drives down a stretch of road and these automated systems will permit rapid identification that a sign is missing and automatically issue the appropriate work order, with priorities given to those signs which could adversely affect safety.

Eventually motorists will have the same convenience now afforded truckers in the issuance of oversize and weight permits. The motorist will call an 800 number and renew their vehicle registration. Eventually, there will not even be a "sticker" required because they will be issued a license plate with an electronic "tag" in the plate. This electronic license plate with be "read" by a police officer as he passes the vehicle. With immediate access to registration information, the police officer will know whether the vehicle is properly registered.

These advanced capabilities will not happen overnight. They will evolve over time. In order to make these services available at the least cost and as quickly as practical, it is necessary to have an appropriate plan. The national architecture for ITS is the plan that allows various subsystems to work cooperatively. Although this plan is just beginning to unfold, it is important to understand how it facilitates the capabilities just described.

The best sources we have at this time for a schematic vision of ITS deployment are the national architecture teams. Figure 1 shows one view of a possible 20-year architecture. While it is unlikely that the architecture in 2015 will look exactly like this, the architecture contemplated in Figure 1 is comprehensive, forward-looking and worth using as a target during early deployment.

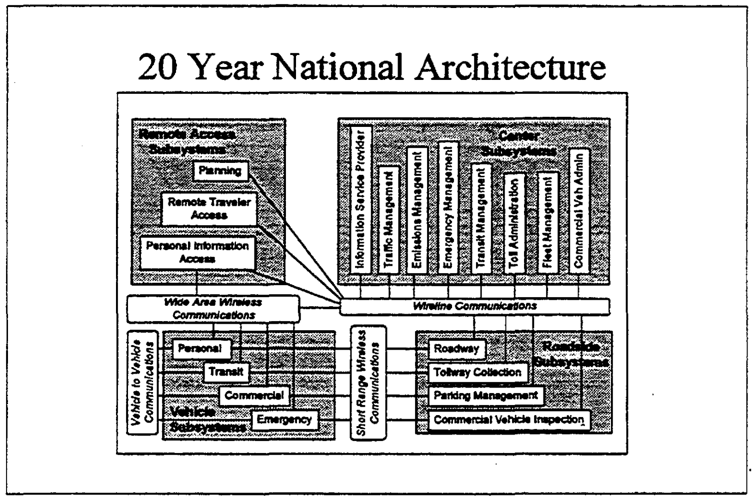

Figure 1. National Architecture 20-Year Framework (*2*)

As will be discussed in detail later, the Federal Highway Administration has identified a subset of that future architecture that represents a nearer term goal, and calls that subset the "intelligent transportation infrastructure" or ITI. That infrastructure is schematically represented in Figure 2. Obviously, the "ITI Architecture" is a scaled-back version of the 20-year architecture, and thus a nearer term vision that ITS planners can use as a target. Most current ITS planners anticipate that the public sector will deploy most of the infrastructure over the near term as private sector markets are identified and developed.

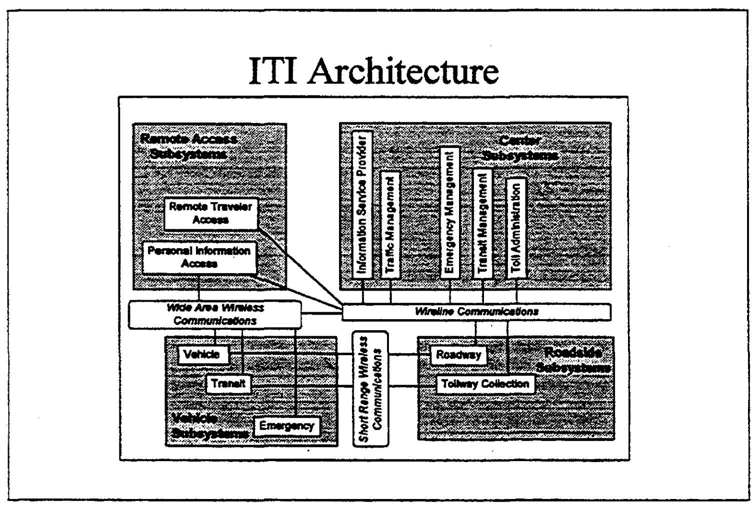

Figure 2. National Architecture Framework for "Intelligent Transportation Infrastructure" (3)

Finally, the architecture that represents the technological present is shown in Figure 3. Most communities have the ability to accomplish the ITS applications represented therein. In most places, this figure represents the basic starting point.

It should be evident that we can already see at least one version of the future evolution of ITS. That future evolution is the basis upon which we can construct plans that begin wherever a community is and moves toward a vision of the future. If a community is very advanced and is nearing the "intelligent transportation infrastructure" represented in Figure 2, then there are a host of services that community can offer in the very near future. On the other hand, if a community has not yet reached the "early architecture" stage, then the services offered will be less in the near term, but that community still has a viable target for planning near term ITS deployment.

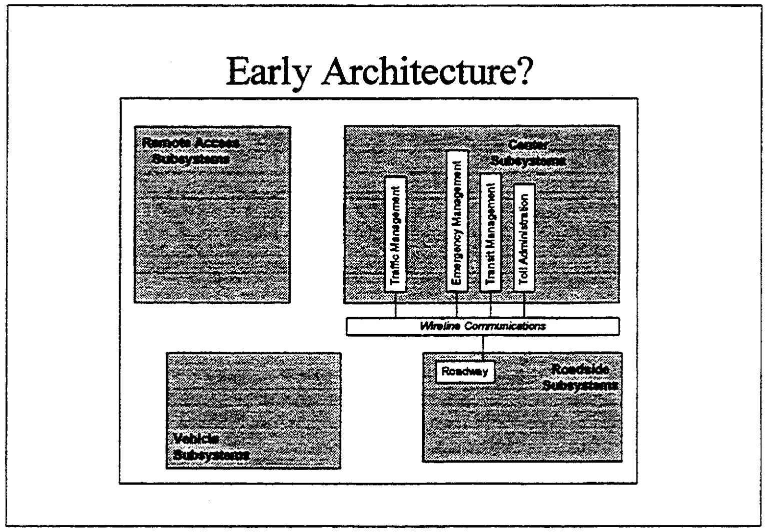

Figure 3. Hypothetical National Architecture Framework for Early Deployment (*3*)

The following chapters provide guidance that will enable TxDOT and constituent communities to accelerate near term (five years) deployment while continuing to observe, plan for, and build toward a future deployment that represents a long-term vision for that community.

CHAPTER TWO

GUIDING PRINCIPLES

GUIDING PRINCIPLES FOR ITS DEPLOYMENT

Because needs, technology and associated applications can change rapidly, an effective deployment strategy must be built on underlying principles that are not affected by rapid technological change. Those principles include:

1. an action orientation,
2. a focus on problem-solving,
3. optimum participation,
4. minimum long term (life cycle) cost,
5. a strategic approach to deployment, and
6. locally-driven deployment.

1. ACTION ORIENTATION

ITS is action oriented. Rapid deployment of building block ITS projects should be promoted, while long-term planning for large scale projects is underway. Staged deployment of systems and subsystems provides near term benefits to the public, allows some flexibility to incorporate evolving technologies, and is more easily adaptable to changing budgetary climates.

2. FOCUS ON PROBLEM-SOLVING

ITS systems and programs must meet an identifiable public need. That need will often be an *information* need. Transportation improvements always address a public need: traffic signals meet a public need by assigning right of way at an intersection while adding lanes to a roadway meets a public need by increasing capacity. In brief, to meet the requirements of this guiding principle, the ITS project/program designer must be able to describe clearly what public need is being satisfied.

If an ITS solution is being contemplated, then the need is probably an information need. The information may be direct information for the traveler, such as that on a changeable message sign, but there are other ways that an information need can be met. The following are some examples:

- An operator in a traffic management center may need information about system conditions to allow him/her to make appropriate decisions regarding ramp metering rates or signal timing for corridor diversion, or other operational changes, which need can be met using video or loop detectors or other kinds of field data.
- Travelers making pre-trip plans can obtain needed information from television or radio

announcements, so that they can make appropriate decisions about route, mode, or departure time.

- On-board transponders can communicate needed information to roadside systems, allowing high-speed preclearance of a commercial vehicle at a point of entry.

Not only does this guiding principle focus the designer on addressing a public need, but it also provides a conceptual model that can facilitate system design by addressing the following questions:

- What is the public need being addressed (what problem is being solved)?
- What action (by traveler, system operator, etc.) is needed?
- What information is needed to allow the proper decision→action to occur?
- What data is needed to create the required information?

3. OPTIMUM PARTICIPATION

Because ITS is information-based, virtually all projects and partners can benefit from shared information. Information sharing reduces redundancies and discrepancies, takes advantage of economies of scale, and improves service to the ultimate customer. Surface transportation systems are interdependent: as the need for increased intermodal and multimodal travel grows, the multi-partner benefits of ITS will become increasingly important. However, information sharing creates a whole new set of compatibility, interfacing, and control problems, which means that it will be crucial to address (or better, avoid) closed or proprietary systems, many of which are already in place.

Increasing the number of partners also broadens the base of support, particularly financial and public relations support. Public sector partners may include other jurisdictions, other functions (e.g., design or planning), other agencies (e.g., law enforcement, EMS, fire), or other disciplines within an agency.

- **Multi Jurisdictional**

  Effective systems cannot begin and end at political boundaries. TxDOT projects should be the first to extend cooperation beyond the right-of-way line. Deployment costs should be borne proportionately, with emphasis on "deployment," not on "proportionately."

- **Multimodal**

  Occasionally, relatively modest additions to "traffic control systems" can significantly benefit other modes, which may be able and willing to pay the additional cost (such as bus priority features added to signal systems or upgrades, the cost of which transit authorities may be willing to fund).

- **Multifunctional (fire, police, etc.)**

  Including public safety elements not only solves real problems, but also adds the strong potential for public support to a project.

- **Multiple Disciplines**

  Disciplines outside traditional transportation engineering and planning, such as communications and public relations, can broaden the perspective of the practitioner and enhance the project.

Private sector partners should be considered whenever possible. Private sector partners will be of the most benefit when a market niche can be identified wherein they can provide the service and reap the rewards. An example of private sector interest is the significant investment that Avis Rent-a-Car is promoting with their in-vehicle route guidance system. In order to gain a market niche, private sector partners may be willing to invest in ITS deployment. This type of relationship will be distinctly different from hiring a private contractor to perform work on behalf of a public agency.

Because the private sector role is evolving, public policy must also evolve. TxDOT must examine current policy regarding private sector participation. Not only could public agency procurement procedures may have to be modified, and resource allocation funding, R&D, planning, design, deployment, and operational procedures may also need to be adjusted to be able to form long-lasting, working partnerships with the private sector.

4. MINIMIZE LONG TERM (LIFE CYCLE) COSTS

Long term costs include not only capital costs, but also the operations, maintenance, and replacement costs associated with an application. Ideally, the ITS project

- balances near term priorities with long term operating costs (an agency isn't stuck with a system that is cheap to purchase and install, but too expensive to operate and maintain, or one that does not do the job and is therefore ineffective);
- maximizes investment, including use of existing facilities;
- maximizes opportunities to incorporate ITS elements into other projects; and
- is consistent with statewide goals and applicable standards.

5. APPROACH DEPLOYMENT STRATEGICALLY

The project/program should logically fit into the overall local ITS planning, as well as the broader transportation plans:

- Deployment planning recognizes that every community and transportation entity has a different starting point--to the maximum extent practical, the project is compatible with existing systems.
- The project uses the building block, or modular approach--the project supports future or expanded deployment, as well as modular upgrades of components.
- Uses geographic location system, where appropriate--because many ITS systems must relate in time and space, an accurate, flexible geographic base will be essential for virtually all projects.
- Identifies and incorporates technology that is flexible, compatible, and expandable, especially for those elements that form the infrastructure backbone.

One frequently expressed concern is that of obsolescence. The principal concern should be for the ability to continue to perform an important function, not whether the technology is always on the cutting edge. For example, some of the on-board systems on the space shuttle utilize microprocessors that are one to two generations old. They are not upgraded because they don't need to be to perform the intended function. A well-designed intelligent transportation system should not be vulnerable to the need for continual high-end upgrades in order to maintain functionality.

6. DEPLOYMENT IS LOCAL

Although TxDOT can promulgate standards and expectations statewide, ultimate deployment success is local and can only be achieved by commitment to local action and continuing coordination. Local-level deployment fosters consistency with other local efforts, reflects community desires, and allows the level of communication and coordination to assure that the project will continue to enjoy support.

The set of needs and available resources will vary from community to community and district to district. "Local deployment" recognizes that viable planning must optimize the local factors of need, resources, vision, and commitment.

CHAPTER THREE

DEPLOYMENT PRIORITIES

DEPLOYMENT PRIORITIES

Some metropolitan and some not-so-metropolitan areas have a very clear idea about what problems they want to tackle initially with ITS deployment. Other areas may be uncertain about how best to proceed ITS deployment. This chapter is intended to provide some initial direction and emphasis that will allow any locale to begin their deployment and clarify their own direction as they become more experienced.

Priority-setting at this stage presents a substantial paradox. Creating partnerships significantly broadens the benefits of many deployed projects. However, adding partners usually adds time to the process and complicates decision-making, thus infringing on the pace of deployment. Therefore, this strategy attempts to identify near term priorities that TxDOT can pursue unilaterally, as well as those that require partnerships with other entities, either public or private.

"Deployment" as used here means the implementation of physical improvements and operational practices to effect the desired outcome.

DEVELOPMENT OF RECOMMENDED PRIORITIES

There are a host of factors that influence the nature and pace of ITS deployment, including the transportation needs, the maturity of available technology, and the placement of the deployment project into the larger scheme. The process of priority development attempts to recognize and incorporate these types of factors. Figure 4 illustrates the essence of the process used.

As mentioned previously, the overall strategy was developed under the direction of the Strategy Development Team (SDT), a group of mid-to-senior level practitioners from throughout the districts and divisions of TxDOT. It was agreed from the beginning that the development of the strategy should support the Texas Transportation Plan. One of the initial efforts of the group was to identify and prioritize the elements of the Plan that could potentially benefit from deployed ITS projects. To that list of possibilities, the SDT added other considerations identified in the 1994 National ITS Program Plan and the 1992 ITS America Strategic Plan, along with elements developed in similar strategies for other states. All of these elements together represented the practitioner's view of near-term ITS opportunities, and would be combined with other efforts to develop a recommended focus.

A joint team of researchers provided the second major type of input. Researchers from the Texas Transportation Institute and the University of Texas at Austin, in cooperation with TxDOT, reviewed all of the "User Service" categories to identify the most likely opportunities. This review was intended to identify two things: first, for which of the 30-odd services will the technology be

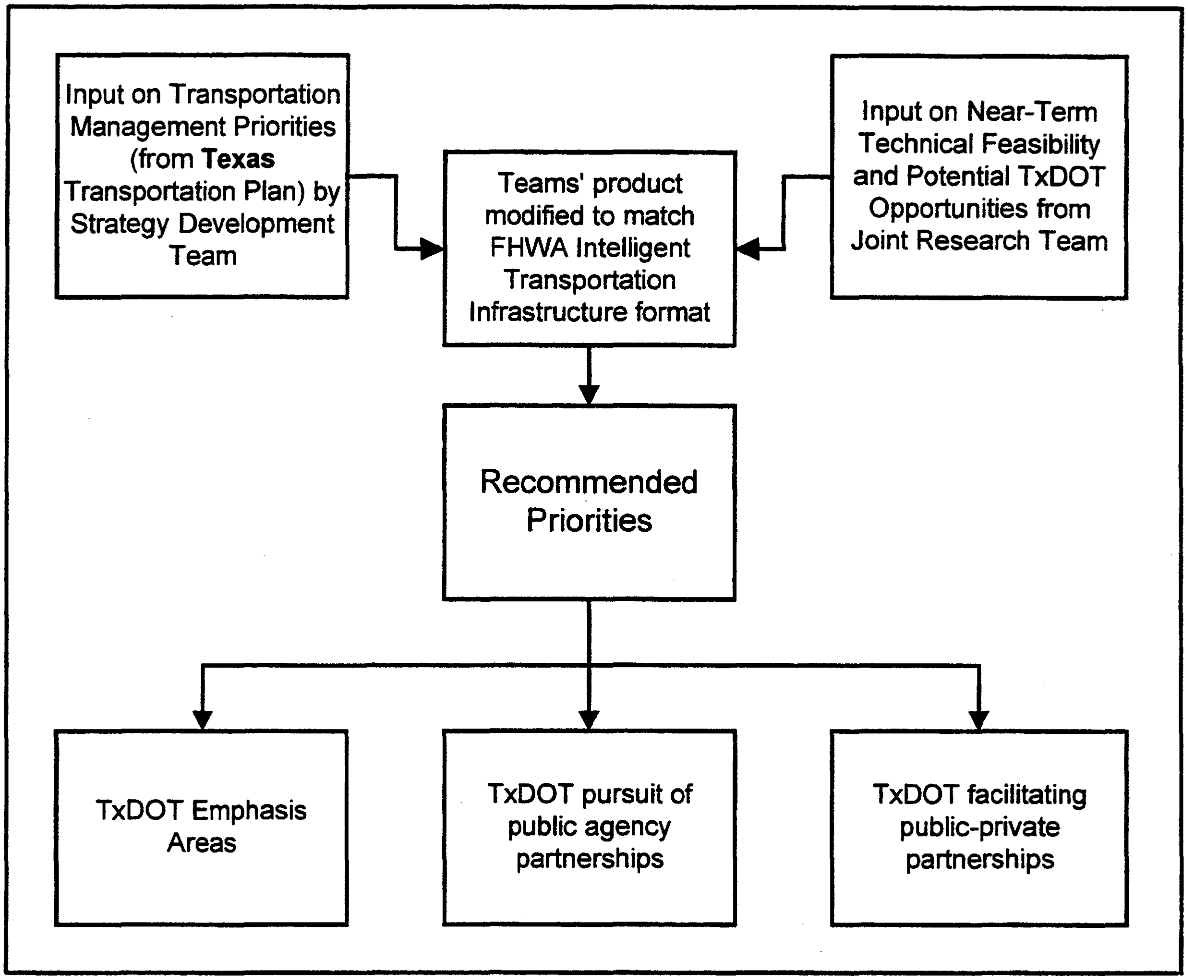

Figure 4. Development of Recommended Deployment Priorities

sufficiently mature within the near term (five years) to support TxDOT's aggressive pursuit, and second, what appeared to be the most productive role for TxDOT in hastening the pace of deployment of each service. This effort was then combined with the effort of the SDT to serve as the Texas input to match with the mainstream direction of the Federal Highway Administration (FHWA).

In 1995 the FHWA provided some consolidated direction for future ITS deployment in the form of the core infrastructure. The core infrastructure, later expanded to the intelligent transportation infrastructure (ITI), was matched against the near-term possibilities identified by the strategy development team and the joint research team. The consolidation from these three perspectives produced to the recommended emphasis areas shown in Table 1.

In this context, emphasis areas differs from priorities in somewhat the same way as strategy differs from plan. Emphasis areas represent departmental intent to concentrate over the near term on certain services. Recognizing that each community will have different needs and resources, the ITS committee concurred that the strategy convey maximum flexibility for local entities to take advantage of opportunities and solve problems.

RECOMMENDED EMPHASIS AREAS

The recommendations for near-term focus by TxDOT fall into three categories: 1) those actions that TxDOT can pursue vigorously while developing partnerships, 2) those areas where TxDOT can play a leadership role in forging the public partnerships needed for a deployment effort, and 3) those areas where TxDOT can begin encouraging public-private partnerships (in some cases leading eventually to private sector markets).

These recommended emphasis areas closely parallel the core infrastructure, but are *not* a prescription for all ITS planning. As always, TxDOT and ITS partners will need to adjust these emphasis areas and each partner's role to match local needs and available resources.

Table 1 summarizes the recommended early emphasis areas for TxDOT, as well as the role TxDOT should consider. The group of columns on the far right, labeled "Deployment Roles," shows the *typical* roles of various entities involved in deployment planning and execution. Consistent with the principle of optimum participation, no one entity should be expected to shoulder all deployment responsibilities. Thus the table shows a concept (not a prescription) for shared responsibility.

Table 1. Recommended Early Emphasis Areas

User Service	TxDOT Near-Term Role	Deployment Roles[1]			
		TxDOT	City/ County	Transit Authority	Private
Traffic Control	Deployment (state roads)	◆	❖	❍	
En-Route Driver Information	Deployment (also facilitate long-term private role)	◆	❖	❍	Info Providers?
Incident Management	Leadership of local partners + Deployment (state roads)	◆	❖	❖	Cellular Providers?
Rail-Highway Grade Crossing Operations	Exploration + Deployment	◆			Railroads
Smart Emergency Systems	Coordination + Deployment	❍	◆		
Pre-trip Travel Information	Leadership (establish policy framework for private sector delivery) + Coordination	❖	◆	◆	Info Providers?
Travel Demand Management	Coordination w/ local entities	❍	◆	◆	
Public Transportation Management	Coordination w/ transit authorities	❍	❍	◆	
En-Route Transit Information	Provide access to real-time system condition data	❍	❍	◆	
Public Travel Security	Coordination of video capabilities w/ transit authorities	❍	❍	◆	
Commercial Vehicle Electronic Clearance	Coordination w/ federal, state, and motor carriers	❖	❍		◆ - Motor Carriers
Commercial Vehicle Administrative Processes	Coordination w/ motor carriers	❖	❍		◆ - Motor Carriers

[1]◆ = Typical Lead Role; ❖ = Alternate Lead Role; ❍ = Typical Support Role

Recommended Emphasis Areas -- *TxDOT-led activities*

Traffic Control

TxDOT should continue the active role in deployment on state roads, both urban and rural, and should initiate dialogue with other entities to promote effective operation between contiguous systems (such as freeway-arterial interfaces). For operational issues that are potentially contentious, like ramp metering, TxDOT should facilitate the public policy discussion to achieve support of local leaders. All interested parties should avoid the tendency to see this and other ITS services primarily as urban tools. For example, the ability to remotely monitor and control hurricane evacuation routes along the coast can be viewed as a form of traffic control.

En-Route Driver Information

Though changeable message signs alongside an urban freeway is the stereotypical image of this service, it spans a wide range of applications. In many parts of Texas, the need to inform the traveling public of unexpected safety risks is more common and pressing than managing freeway congestion. Thus the ability to detect rising water from flash floods in the Hill Country or ice on bridges in the Panhandle, and to warn the public accordingly is another example of en-route (or pre-trip) traveler information. This service area may offer future opportunities for private sector participation. TxDOT should begin examining policies that facilitate private sector involvement, while protecting public responsibilities.

Incident Management

TxDOT can play a major leadership role in incident management, especially the deployment of technology on state roads, but effective response to incidents can only be achieved through local cooperation and coordination. TxDOT should facilitate the dialogue needed to achieve a local consensus about the purpose, value, and roles in incident management.

Rail-Highway Grade Crossing Operations

Because the opportunities for information/data interchange between railroads and TxDOT are not clearly defined, the TxDOT role is shown as "exploration + deployment." This area could be among the first to reflect true public-private partnership. Data sharing, especially regarding the streamlining of the rail-highway interface have significant safety potential. Furthermore, the railroad industry has been practicing many of the forms of automated control for many years, and may be able to share transferable experience with TxDOT and other public entities.

Recommended Emphasis Areas -- *Public agency partnerships*

The extension of traffic control, en-route driver information, and incident management services beyond the state system would benefit travelers on city and county roadway systems. Several services can be provided to the public via partnerships between TxDOT and other public entities, usually cities, counties, or transit agencies (though some state agencies could become partners). Partnerships will be necessary in these areas because some aspect of deployment, such as capital funding or construction, or support for continuing maintenance and operation, will be the partial responsibility of another public entity.

Smart Emergency Services

Efficient management and use of equipment is an important contributor to a safe transportation network. Typical "smart" systems can provide emergency services with automated vehicle location to facilitate emergency dispatch and traffic signal preemption to improve safety. TxDOT should assist the local emergency agencies in deployment of these services, especially with regard to hardware that TxDOT can include in the reconstruction or upgrade of traffic signals on state routes.

Pre-Trip Travel Information

This service can be based on virtually the same data as en-route driver information, but delivered at a time when travelers have more options available to them. In many respects, pre-trip traveler information is a mechanism for voluntary travel demand management. This service is envisioned as a market opportunity for private sector "information service providers." TxDOT should begin examining a policy framework that would allow appropriate access and involvement by private sector entities.

Demand Management and Operations

More aggressive travel demand management is a matter of metropolitan area public policy and requires mutually supportive efforts by all pertinent entities. TxDOT should coordinate with local entities to identify those efforts that can be supported by ITS technologies.

Public Transportation Operations

Partnership with transit entities, particularly metropolitan transit authorities, offer great potential to broaden the service base for little or no additional investment by TxDOT. Many of the transit services are dependent on either the real-time traffic condition database derived from the basic services, or on the communications network deployed by TxDOT for the provision of other services. *Public transportation management* and *en-route transit information* are two key services that may be available to transit authorities with marginal additional investment. Further, where TxDOT or others deploy video for incident detection or verification, those facilities could potentially aid transit authorities with *public travel security*. Again, local needs will provide indications of the most fruitful opportunities.

Recommended Emphasis Area -- *Private sector participation*

It appears likely that most of the near-term private sector participation in ITS will come from opportunities to streamline current activities, rather than creation of new services. Examples of near-term possibilities include *commercial vehicle electronic clearance*, which is getting very serious interest along the Mexican border, and a likely companion service, *commercial vehicle administrative processes*. The COVE study, a multistate effort that includes Texas, has these types of services under careful examination and, in concert with the motor carrier industry, could have deployment under way during the near-term (*5*). A key advantage to continuing the multi-state effort is that it presents a significant economy of scale to the industry, increasing the likelihood and pace of deployment.

Annual Priority Review Needed

The technologies and opportunities in ITS change rapidly. Likewise, community needs change, though not as often. One set of emphasis areas cannot apply per se to every community, nor will the priorities remain constant over time. Therefore, it is recommended that these emphasis areas be revisited periodically, at the local and state level, to ensure that the overall direction is still consistent and focused.

Policy Analysis

In addition to setting and reviewing priorities for ITS deployment, TxDOT needs to provide policy direction in four key areas:

1) private sector participation,
2) funding capital improvements and O&M,
3) development of ITS and related standards, and
4) achieving seamless integration across jurisdictional lines.

TxDOT has formed teams to examine current policy and draft appropriate policies following the comment period.

CHAPTER FOUR

ROLE OF TxDOT IN ITS DEPLOYMENT

ROLE OF TXDOT IN ITS DEPLOYMENT

The role of TxDOT varies widely in ITS deployment. Those roles could include any or all of the following:

- the primary deployment role for a ramp metering project on a freeway,
- a leadership/coordination role in the development or revitalization of an incident management program on that same freeway,
- a listening role in understanding the needs of local partners and how those needs translate into requirements of the communications infrastructure,
- a policy-setting or oversight role in setting appropriate standards to assure statewide compatibility, or
- a facilitation role in making it possible for private sector information providers to gain appropriate access to the data collection system.

TxDOT's role will be one of leadership, but should reflect ownership only of those elements of ITS necessary to properly operate TxDOT roadways.

In many respects, the current roadway system model is an excellent starting place to define the role of TxDOT and other entities. TxDOT has an extensive network in each community, usually comprised of freeways and some of the primary arterials. Locally built and controlled roadways connect to the TxDOT systems and provide a network that is "seamless" to the user. That type of interaction in ITS deployment would serve both TxDOT and local entities well. In urban areas, TxDOT could/would provide a system that operates well on its own and accommodates other transportation agencies that would want to link up to the system.

The traditional meeting point in the TxDOT/local relationship is the right-of-way (ROW) line. For most purposes, the ROW line will divide responsibilities, with each entity being responsible for actions on their side of the line. Because electronic systems function differently than roadway systems, dividing responsibility at the ROW line could seriously impede the objective of "seamless" operation. An early task of TxDOT will be to identify a viable approach to overcoming this obstacle. Though there may be some technological difficulties to overcome, the institutional hurdles could be the hardest to clear.

Extending beyond the ROW line may be desirable in individual circumstances. Because ITS deployment should optimize the number of partners involved, there may be occasions where TxDOT should participate "beyond the ROW line" in order to assist another partner in deploying a technology that meets the partner's needs. It should be TxDOT policy for the districts and divisions to have the flexibility to determine and evaluate these opportunities.

DEPLOYMENT OF COMMUNICATIONS INFRASTRUCTURE

TxDOT will play an important role in the communications infrastructure. In most metropolitan areas, TxDOT will have significant deployment of ITS applications along roadways on the state system. In developing communication plans for linking these applications, TxDOT should consider potential future partners from at least two areas --other public sector agencies and the sought-after private sector. In establishing communications infrastructure capacity, then, TxDOT should consider at least three levels emanating from these potential partnerships. The first is TxDOT alone, designing the infrastructure to meet the needs of planned TxDOT deployments. The second includes discussions with other public sector entities to ascertain near-term plans, and incorporating appropriate additional capacity into the TxDOT system design. The final consideration is whether future private sector applications should be accounted for in system design. Maximizing the number of partners should be the guiding principle, but there may be equity issues, particularly with private sector partners. Some of the analysis necessary to arrive at a conceptual answer to some of these questions will come from the TxDOT Telecommunications ROW Task Force, which is dealing with similar issues at the time of this writing.

PLANNING AND COORDINATION

The metropolitan planning organization (MPO) could be the vehicle for initiating or resuming the interagency communication necessary for successful local deployment of ITS. The MPOs represent both a formal opportunity for cooperation and a potential funding source for mutually desired projects that might otherwise go unfunded. It may be appropriate for MPOs to form staff level task forces from constituent agencies specifically to address mutual ITS deployment, including the pursuit of funding. It will be important for all such task groups to include appropriate management expertise to ensure that focus on problem-solving is maintained, rather than a focus on technology.

FUNDING

TxDOT should aggressively pursue deployment funding for purposes of unilateral implementation on state routes and for TxDOT's share of public and/or private partnerships. It is recommended that TxDOT not attempt to provide funding for a local entity's share of a joint project. Even if such funding were possible, the potential financial drain and the wide variations in priorities from locale to locale could adversely affect the deployment schedule. TxDOT should work with local entities through the MPO and other locally formed coordination mechanisms to achieve proportionate deployment responsibilities. In the event that local entities cannot fund a proportionate share of a multijurisdiction project, TxDOT should proceed with deployment using the state facilities, maintaining a capability to incorporate the local entities at a later date.

MAINTENANCE AND OPERATIONS

As the strength of ITS is in broad deployment and sustained operations, an implementation decision should consider long term maintenance and operations cost. The importance of this commitment is emphasized by the building block nature of anticipated deployment packages, which shows that the previous block needs to be functioning adequately to accomplish the purposes of successive deployments. Some of the ITS technologies offer clear opportunities to minimize maintenance and operations costs, such as those that provide remote diagnostics, or those that allow a single operations staff member to perform functions previously requiring several personnel. ITS planners and practitioners should always examine those technologies and techniques that have the potential of reducing personnel and maintenance requirements.

At present there is little known documentation on the appropriate funding levels for ITS or other aspects of transportation management. A report from the International Institute of Transportation Engineers (*6*) and an ongoing TxDOT SPR research project (*7*) should bring some structure, data and estimation techniques to this area within the coming year.

An easily overlooked aspect of deployment is the human element. An investment in technology by TxDOT warrants a commensurate investment in the personnel that must operate these advanced systems. TxDOT must be able to attract and retain the personnel needed to gain maximum benefit from deployed technology.

TxDOT INTERNAL ROLES

As recognized in major national efforts, ITS is very locally-focused, meaning that the districts are going to be the key organizational elements in ITS deployment. Except for those technologies and services that are planned and executed from headquarters, such as commercial vehicle inspection and weigh stations, TxDOT districts will represent the departments involvement in ITS. Within the established policy framework, each district will serve as an independent local partner.

Similar to the current role, divisions will identify key statewide issues, develop and promulgate (with District involvement) appropriate standards and practices, and monitor overall effectiveness of ITS deployment.

CHAPTER FIVE

COSTS AND BENEFITS OF ITS

COSTS AND BENEFITS OF ITS

The anticipated costs and benefits information of ITS deployment are universally sought by implementing agencies. This information is critical to the significant investment decisions that public and private sector entities will be making over the next several years. Public sector decisions are doubly important because they may represent a substitution for capacity-adding construction, and they may serve to enhance the market potential for future private sector investment.

Unfortunately, the field is too new to produce highly predictable or well defined cost/benefit relationships. This chapter cites the considerable anecdotal information about benefits that has been assembled thus far, as well as some very general extensions of potential metropolitan area costs. For the present, these estimates of benefits and costs should be viewed as indicators of potential rather than reproducible calculations.

COSTS OF ITS DEPLOYMENT

Actual deployment costs will be project-locale specific. The FHWA has compiled some "typical" urban area estimates for the deployment of core infrastructure. In developing these estimates, they make numerous well-documented assumptions, so that the estimates can be refined to more closely matched local conditions.

In an effort to bring some gross scale to this discussion, Table 2 summarizes variable costs estimated for the major categories; lump sum cost estimates for the remaining categories are shown in Table 3. *Understanding the underlying assumptions is crucial to accurate interpretation.* The reader is referred to Appendix E for the FHWA report.

The values in Table 2 are *averages* computed from the FHWA report, rather than the gross estimated total category costs reported there. The gross costs varied greatly by city size (as would be expected) and assumed that the entire freeway and arterial systems were all upgraded to meet core infrastructure standards. (In the case of the example cities, 400 freeway miles and 2500 signalized intersections.) While that level of coverage should be the eventual goal for all cities, the gross totals do not readily facilitate the development of estimates for phased implementation, which is the route most communities will take.

Most of the differences between city size is related to the numbers of freeway miles and signalized intersections. When the variable capital costs shown in Table 2 are expressed as "per mile" or "per intersection" values, the differences of city size is negligible. Generally speaking, smaller cities will spend less on loop detectors per mile because freeways and arterials are assumed to be wider in larger cities. Conversely, the unit price of changeable message signs is

Table 2. Gross Estimates of Variable Core Infrastructure Costs[1]					
Function	**ITS Element**	**Cost per Freeway Mile**		**Cost per Arterial Intersection**	
		Capital Cost	Annual O&M Cost	Capital Cost	Annual O&M Cost
Surveillance	Closed Circuit TV	$20,000	$1,000	$2,000	$1,000
	Loops	$10,000	$640	$8,000	$480
	Video			$4,000	$200
Traveler Information	Changeable Message Signs	$50,000	$2,500	$1,000	$40
	Ramp Meters	$40,000	$2,000		
	Signal Upgrades			$5,000	$250
Communication	Call Boxes	$20,000			
	Fiber Optics	$240,000	$12,000		
	Signal Communications			$10,000	$500
TOTALS		$380,000	$20,000	$30,000	$2,500

expected to be higher because the number of signs needed does not decrease proportionately with system mileage. Overall, smaller cities should expect aggregate unit costs (per mile, etc.) within 10 percent of that of larger cities.

The lump sum costs in Table 3 will obviously vary depending on which facilities are given community needs. Transportation Management Centers (TMCs) are estimated to cost about $5 million each, including computers, software, facilities and communication. To the degree that the need for additional TMCs can be reduced (large city assumption is six total), added costs will be reduced. Similarly, if Traveler Information Centers, Emergency Management Centers and Transit Management Centers can be consolidated with Transportation Management Centers, then there will be some significant savings not reflected in the table.

Other costs in Table 3 are variable depending on the community, but do not necessarily relate to freeway mileage or signalized intersections. Emergency Vehicle Services includes the on-board equipment needed by emergency response vehicles, estimated at $300 per vehicle. Incident Management Equipment is very similar to traditional courtesy patrol equipment, with portable changeable message sign and portable highway advisory radio systems included. Electronic Toll Collection and Electronic Fare Payment systems will obviously vary with the size of the system.

[1]Assumes full city-wide deployment and other significant assumptions; see full report for details.

Table 3. Gross Estimates of Lump Sum Core Infrastructure Costs[a]

ELEMENTS	Large[b] City		Medium City		Small City	
	O&M[c] Cost ($000's)	Capital Cost ($000's)	O&M Cost ($000's)	Capital Cost ($000's)	O&M Cost ($000's)	Capital Cost ($000's)
Transportation Management Centers[d]	12,270	29,400	6,306	15,724	925	3,496
Traveler Information Center	3,720	10,402	2,929	8,082	1,159	4,671
Transit Management Center	372	4,430	278	3,652	206	3,128
Emergency Management Centers	370	4,400	277	3,532	205	3,098
Transit Vehicle Interfaces[e]	630	12,600	378	7,560	32	630
Emergency Vehicle Services[f]	50	990	38	750	8	150
Incident Management Equipment[g]	2,295	8,675	2,460	3,325	0	0
System Design & Integration	0	5,400	0	4,320	0	3,780
Electronic Toll Collection Systems	7,310	8,675	2,460	3,325	0	0
Electronic Fare Payment System[h]	4,366	103,320	2,657	62,732	0	0

[a] Impossible to accurately interpret table without assumptions -- see Appendix E for details on assumptions. Key assumptions reprinted below.

[b] City size: Large (>750,000); Medium (200,000 - 750,000); Small (50,000-200,000)

[c] Annual O&M costs assumed to be 5% of Capital Costs

[d] Number of Transportation Management Centers Assumed: Large -- 6; Medium -- 3; Small -- 0

[e] Assumes $6300 per vehicle capital cost

[f] Assumes $300 per vehicle capital cost

[g] Assumed Large City Capital Costs: Vehicles -- 40 @ $50,000 each; Portable HAR -- 10 @ $50,000 each; Portable CMS -- 15 @ $30,000 each

[h] Assumed Fleet Size: Large -- 2000 buses; Medium -- 1200 buses; Small -- 0 buses

BENEFITS OF ITS DEPLOYMENT

Benefits are also project-locale specific. This section attempts to identify the types and range of benefits that have accrued from projects deployed to date. As deployment documentation continues, the breadth, accuracy and applicability of benefit analyses will improve.

Table 4. Typical Benefits[1] -- Intelligent Transportation Infrastructure

Freeway Management Systems. A formal program for improving traffic flow on high-volume roadway segments via adjustments to ramp metering rates, variable message signs, and highway advisory radio messages based on real-time traffic surveillance. Ramp metering in Minneapolis, MN increased freeway speeds by 35 percent and freeway capacity by 22 percent and reduced accident rates by 31 percent.

Operations Improvement	Safety Improvement	Environmental Improvement		
Travel Time - 20 - 48 % Travel Speed - 16 - 62 % Freeway Capacity - 17 - 25 %	Accident Rate - 15 - 50 %	CO - 122,000 tons yearly	HC - 1400 tons yearly	NOx - 1200 tons yearly
		Fuel Consumption 41 %		

Traffic Signal Systems Benefits. Optimize traffic flow by adjusting signal timing and patterns in response to real-time traffic data. Coordinated, computerized traffic signals in Lexington, KY reduced stop-and-go traffic delays by about 40 percent and reduced accidents by 31 percent.

Operations Improvement	Environmental Improvement		
Travel Time - 8 - 15 % Travel Speed - 14 - 22 % Vehicle Stops - 0 - 35 % Delay - 17 - 37 %	CO - 5 - 13 %	HC - 4 - 10 %	
	Fuel Consumption 6 - 12 %		

Incident Management Program Benefits. A program to identify and respond to vehicle accidents and breakdowns with appropriate emergency services and restore roadway to full service. The incident management program in Chicago, IL has reduced the time to clear incidents by 50 percent.

Operations Improvement	Safety Improvement
Travel Time - 10 - 42 % Incident Clearance Time - 8 minutes for stalls 5 -7 minutes for wrecker response	Fatalities - 10 %

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[1]Source: U.S. Department of Transportation

Table 4. Typical Benefits[2] -- (con't.)

<table>
<tr><td colspan="4">Traveler Information System Benefits. Collect, analyze, and distribute accurate, reliable, and timely travel information to travelers and commercial carriers when and where they want it. Montgomery County, MD broadcasts traffic conditions on major roadways to 180,000 homes via cable television.</td></tr>
<tr><th>Operations Improvement</th><th colspan="3">Environmental Improvement</th></tr>
<tr><td rowspan="2">Travel Time - 20 % in incident conditions,
8 - 20 % for equipped vehicles
Delay - 1900 vehicle hours/incident</td><td>VOC - 25 %</td><td>HC - 33 %</td><td>NOx - 1.5 %</td></tr>
<tr><td colspan="3">Fuel Consumption - 6 - 12 %</td></tr>
<tr><td colspan="4">Transit Management System Benefits. A program for managing bus operations based on real-time bus location information. Using automatic vehicle location (AVL) data to optimize bus routes and reduce run times allowed Kansas City, MO to eliminate seven buses from its fleet of 200. The savings paid for the system in two years.</td></tr>
<tr><th colspan="4">Operations Improvement</th></tr>
<tr><td colspan="4">Travel Time - 15-18%   Service Reliability - 12-23%
Security - response time 1 minute   Cost Effectiveness - 45% annual return on investment</td></tr>
<tr><td colspan="4">Electronic Toll Collection System Benefits. A system to allow nonstop toll payment. The Oklahoma Turnpike's electronic toll collection system minimizes driver delays and has cut the State's operational cost per lane for toll collection by 91 percent.</td></tr>
<tr><th>Operations Improvement</th><th colspan="3">Environmental Improvement</th></tr>
<tr><td rowspan="2">Operating Expenses - 90 %
Capacity - 250 %</td><td>CO - 72 %</td><td>HC - 83 %</td><td>NO_x - 45 %</td></tr>
<tr><td colspan="3">Fuel Consumption - 6 - 12 %</td></tr>
<tr><td colspan="4">Electronic Fare Payment System Benefits. A system to consolidate all transit and parking transactions onto one card to add convenience for users and provide centralized information to transit agency managers. In Los Angeles, CA the benefits of Smart Cards were shown to exceed the cost by more than double.</td></tr>
<tr><th>Operations Improvement</th><th colspan="3">Environmental Improvement</th></tr>
<tr><td rowspan="2">Patron Popularity - 90 % usage
Fare Collection - 3 - 30 %
Data Collection Costs - $ 1.5 - 5M less</td><td>CO - 72%</td><td>HC - 83%</td><td>NO_x - 45%</td></tr>
<tr><td colspan="3">Fuel Consumption - 6-12%</td></tr>
</table>

[2]Source: U.S. Department of Transportation

One of the most significant benefits is also fairly difficult to measure—costs avoided or postponed. In many cases ITS technologies can be deployed to avoid or postpone the need to add capacity or make other significant improvements. Though the variation in those costs is wide, it is safe to say that most urban capacity additions would cost many millions of dollars per mile.

Deployed ITS projects, potentially achieving many of the same benefits, can be a fraction of the costs of more traditional capacity expansions.

The following overview of benefits is taken from the Mitre Corporation report entitled, "Assessment of ITS Benefits -- Early Results" (*9*). Following the format of that report, the benefits are categorized according to the structure of the five National ITS Program goals (*10*).

Improve The Safety Of The Nation's Surface Transportation System

The use of video surveillance for traffic law enforcement in London has reduced speeds, accidents and severity significantly, most notably a 50 percent reduction in fatalities. Advanced products employing lane-keeping and collision avoidance technologies are projected to prevent rural and urban accidents, for a combined annual savings of $700 million. Deployment of electronic clearance, inspection procedures and vehicle performance monitoring for commercial vehicles has significantly reduced staffing requirements, as well as yielded a reduction of 2,500 - 3,500 accidents annually.

Increase Operational Efficiency And Capacity Of The Surface Transportation System

Long-term ramp metering projects in Minneapolis and Seattle have shown significant improvements in freeway capacity utilization, concurrent with reductions of up to 62 percent in accident rates. New York estimates that the INFORM program, which uses a combination of motorist information and traffic control strategies, saves in excess of 300,000 vehicle-hours of delay annually. Route guidance pilot studies using in-vehicle displays are showing significant reductions in errant routing, and with that, an increased willingness to divert from a main route when congested by an incident. Incident management programs deployed around the nation are reducing response time to incidents and significantly reducing the potential for secondary accidents (benefit cost ratios range from 2:1 to 10:1). Transit properties using vehicle navigation systems in combination with computer aided dispatch are reporting on-time performance improvements ranging from 12-28 percent.

Reduce Energy And Environmental Costs Associated With Traffic Congestions

Though overall emissions benefits are expected to be small, the use of technology to identify and pursue "gross" polluting vehicles has been promising. Use of improved traveler information in

Seattle and Boston influenced 5-10 percent of callers to change travel mode, though the overall number was very small compared to driving population. Significant reductions in emissions are anticipated at toll plazas using high-speed electronic toll collection. Corridor management analysis and applications have significant benefit to non-attainment areas; in some cases, ITS-oriented improvements may be the only viable near-term options available to improve air quality. Traffic light synchronization projects in Texas demonstrated significant reductions in emissions.

Enhance Present And Future Productivity

Use of electronic toll collection is estimated to pay for itself in one year for the collecting entity and two years for the traveler. One Oklahoma study showed that annual operating costs of an automated lane were less than 1/10 that of an attended lane. Some commercial vehicle operators have deployed some basic on-board technologies and significantly improved driver turnover and vehicle utilization, thus improving operating ratios by 4-5%. Deployment of commercial vehicle related technologies benefit regulatory bodies as well -- the HELP/ Crescent Project estimated that electronic clearance and compliance technologies would produce a nearly 5:1 benefit:cost ratio in capital and operating costs, while the COVE Study produced estimates ranging from 5:1 to 8:1. Transit operators have reported that using bus priority on the traffic signal systems reduced both bus travel time and passenger wait time. The Texas Traffic Light Synchronization program estimated a benefit:cost ratio for that effort at 62:1, including annual savings of $43 million in delay.

Enhance The Personal Mobility And The Convenience And Comfort Of The Surface Transportation System

The addition of Automatic Vehicle Locator (AVL) and Computer Aided Dispatch (CAD) technologies to transit vehicles allows those transit systems to increase the security of the traveler. Traveler information kiosks have also increased the amount of transit information available to potential patrons. While benefits of these improvements are not readily quantified, they aid the transit provider in overcoming two of the biggest impediments to an increased mode share -- traveler security and knowledge of service availability.

SUMMARY

As indicated under Guiding Principles, an ITS project must address a public need. Conceivably a project may solve a problem and be an excellent expenditure of public funds, but defy *credible* calculation of benefits. For the near term, justification of most ITS projects will continue to need stand-alone analysis. "Appendix A -- Project Evaluation" provides a framework for assessing the public benefit that is derived from candidate ITS efforts. Those benefits will typically reflect the improvements in effectiveness and efficiency of the transportation system. The evaluation will consider the intangible (and not easily quantified) benefits of a project, as well as the tangible (and presumably quantifiable) benefits. As more quantifiable benefit data are accumulated, the ability to justify projects as a class will evolve, as will the ability to use "typical" benefit:cost ratios to rank ITS projects against other improvements in the decision-making process.

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APPENDICES

APPENDIX A

Project Evaluation

PROJECT EVALUATION

Allocating limited resources will continue to be a difficult task, at both the local and statewide level. A method of comparing alternatives between ITS deployment and more conventional approaches, and between ITS projects, is essential to assure maximum benefit from the resources available. This evaluation approach is applicable at either the local or statewide level.

EVALUATION METHODOLOGY

Effective evaluation is a "thought process," not a calculation. Although many of the costs and benefits in ITS projects can be quantified, judgment of intangible benefits will also play a very important role. The focus is on maximum benefit for all stakeholders -- including public entities, transportation system users, taxpayers, and private sector partners -- measured by effectiveness of total public investment.

The primary forces in project evaluation are **effectiveness** and **efficiency**. **Effectiveness** evaluates the non-monetary value of the project in meeting community needs. The strongest projects will be those that meet a variety of community transportation needs, especially multi-modal, multi-jurisdictional, and multi-functional needs. **Efficiency** evaluates the benefit to the community for dollars spent. Such benefits are usually measured in dollars and the strongest projects will be those with the highest return on **public** investment -- especially in benefits readily recognized by the public, such as improved flow or reduced waiting time.

EVALUATION CRITERIA

As the primary forces in project evaluation, efficiency and effectiveness are also the broad categories into which the individual criteria for ranking ITS projects are grouped. Factors concerned with project effectiveness include safety, service integration, implementation history, community support, commuting alternatives, and staff comfort with new technology. Numerous factors contribute to project efficiency; examples include return on investment, innovation in funding, and opportunities for private sector participation. All criteria for meeting the project requirements for effectiveness and efficiency are discussed below.

Effectiveness

One factor to consider in determining whether maximum effectiveness is achieved by the project is the impact on public safety. Whether in reduced accidents, improved emergency response, or increased personal security, it is important to demonstrate safety benefits as important products of ITS projects. Another measure of a project's effectiveness is the extent to which it includes other entities (other than the implementing entity/agency) or functions for integration and coordination of services. This factor addresses one of the potential strengths of ITS projects by assessing whether potential multi-jurisdiction, mode, and function opportunities have been explored.

Effectiveness can be maintained in the development of ITS projects by selecting those ITS providers with a history of success as project leaders. Entities with a "track record" of successful implementation should be accorded some priority for getting things done. Insistence on the timely delivery of quality ITS products will insure the maximum return on investment.

Projects that meet multiple community goals, like public safety, can add credibility, financial support and public understanding to current and future projects. Such projects have the potential to increase public interest and support for the ITS effort. One other method for ITS to influence travelers is by supporting projects that produce worthwhile, long-term changes in travel behavior. All other factors being equal, projects that encourage or provide incentive for increased occupancy or non-peak driving should be rated above those that further peak-period congestion.

Finally, the staff of the implementing agency should have complete confidence in their ITS technology and they should be aware of its limitations. Comfort of maintenance and operations personnel with new approaches should be considered in project selection. ITS applications using modular, proven components -- possibly from other industries -- will take precedence over custom-developed technology applications. With such an approach, there is much greater long-term ITS product support and straightforward problem-solving in day-to-day operations. While some ITS technologies may be new to transportation, it is essential that they not be unproven technologies altogether.

Efficiency

Maximum use of available public resources is assured by selecting those ITS projects which provide the greatest return on public investment. To the degree calculable, the public benefit must be computed over the investment period. Also, the most efficient ITS projects are also those which follow a realistic funding approach. While budget realism should be the last cut made in ITS project selection, proposed projects should consider not only the initial capital expense, but also the long term operations and maintenance expense, and whether that O&M support is viable. Projects that are implemented and then discontinued, or gutted for lack of funding, hurt the credibility of all transportation service providers.

All ITS projects should be assessed according to their realistic, expected total public cost and total public benefit. The assessment should consider the total costs and benefits to users and non-users and to involved public agencies as well as non-participating agencies. Total direct and indirect aspects should be considered, if not calculated, in making final selection decisions.

Innovation in funding and financing also increases the efficiency of ITS projects. Added support should be accorded those projects that succeed in identifying non-traditional funding for capital improvements or associated operations and maintenance. Support for the projects can be external, whether from the private sector or other public agencies, or it can result from a self-sustaining ITS implementation. Such projects produce revenues that can be used to sustain the ongoing effort. Examples of projects that are internally supported are those where private sector participation yields sufficient funds to cover project O&M; and, projects that generate data that is marketable in the development or real estate industries. A project that attracts supporting funds should be allowed to keep those funds for O&M as an incentive to broaden the funding base.

For the full potential of ITS to be realized, the private sector must become an active player with government agencies. Therefore, ITS projects with an opportunity for private sector participation should be encouraged. Providing opportunities for the private sector to test potential markets should be a very high priority until the potential for private sector participation has been raised.

ITS projects with the potential to capitalize on existing or planned projects offer an opportunity to "leverage" project funds and produce functioning ITS systems at lower cost. Other factors being equal, ITS projects that can be incorporated into larger construction or operations improvements should be treated favorably over those that require ITS-only construction. Similarly, projects that can take advantage of opportunities for multi-jurisdictional, multi-modal, or multi-functional cooperation or public/private cooperation are to be encouraged. Projects that can be incorporated into the efforts of other public or private sector entities should receive support, even if specific deployment might not have the next top priority. Such projects can not only leverage funds, but they can also foster mutually beneficial relationships.

APPENDIX B

Draft Deployment Priorities For Each User Service

DRAFT DEPLOYMENT PRIORITIES FOR EACH USER SERVICE

This appendix addresses the likely deployment scenario and TxDOT's near term role for each User Service identified in the National Program Plan.

TRAVEL AND TRANSPORTATION MANAGEMENT

The Travel and Transportation Management user services were grouped in a single bundle because of the information they share about the surface transportation system. These services collect and process information about the surface transportation system, and provide commands to various traffic control devices. Travel management services disseminate this information to the traveler. When used in concert, these services can provide a comprehensive travel and transportation management system. These services also provide information to support the Travel Demand Management and the Public Transportation Operations bundles. Thus, the Travel and Transportation Management bundle will be of interest to transportation policy makers, public and private sector operators of transportation management centers, those involved in incident response or travel demand management, and private sector vendors supplying travel information products and services.

* <u>En-Route Driver Information</u>

  Provides driver advisories and information for convenience and safety.

Deployment Scenario: Near term focus will be on roadside driver advisories; since in-vehicle information is probably beyond the initial five-year time frame, but a consideration in other infrastructure development.

Near Term Role for TxDOT: TxDOT role should be to establish policy framework to facilitate private sector service delivery. That role could include a range of actions: providing infrastructure for data collection; franchising of service providers; managing access to data; establishing standards for information dissemination. TxDOT role will be affected by the policy position of the Department on private sector participation. The public sector in general, and TxDOT specifically, should evaluate opportunities to provide public safety information, particularly in rural areas. Existing and in-progress deployments should continue, subject to a rigorous review of specific public needs being addressed with each application. TxDOT should also remain alert to emerging in-vehicle driver communication technology that could have implications for information dissemination and roadside subsystems.

* <u>Route Guidance</u>

  Provides travelers with simple instructions on how to best reach their destinations.

Deployment Scenario: These technologies are not sufficiently mature to anticipate TxDOT involvement within the five-year time frame. Most deployment will be private sector. Public sector role principally USDOT.

Near Term Role for TxDOT: Maintain awareness of evolving technologies.

* <u>Traveler Services Information</u>

Provides a business directory, or "yellow pages," of service information.

Deployment Scenario: These services will be primarily consumer services, thus there is no apparent government role in service delivery, unless it becomes necessary to franchise service providers. May present opportunity to consider joint access to traveler; may be medium for communicating with traveler, particularly Travel and Information Services.

Near Term Role for TxDOT: Maintain awareness of evolving technologies.

* <u>Traffic Control and Management</u>

Manages the movement of traffic on streets and highways.

Deployment Scenario: traffic and transportation management agencies will continue to deploy and integrate systems to improve traffic flow, provide appropriate preferential treatment and minimize congestion. Expanded sharing of real-time traffic information collected will be a central goal.

Near Term Role for TxDOT: Responsible for deployment on State network; key coordination role with locals on arterials, and on freeway - arterial system interface.

* <u>Rail-Highway Grade Crossing Safety</u>

Provides information on the interaction of railroad traffic stream and the manner in which it will impact the roadway traffic stream.

Deployment Scenario: In the near term the primary opportunities will be in researching effective ways of sharing information between the two traffic streams to improve safety of each.

Near Term Role for TxDOT: Partnership effort with railroads crossing TxDOT system to pilot automated exchange of real-time information.

* <u>Incident Management</u>

Helps public and private organizations to quickly identify incidents and implement a response *to minimize their effects on traffic.*

Deployment Scenario: Primary agencies in deployment will be traffic management and public safety (law enforcement). Incident management policy and commitment in each locale should drive deployment; deployment commitments should follow firm policy commitments.

Near Term Role for TxDOT: Convene incident management teams in metropolitan areas. Lead in identifying policy issues and options. Lead in identifying technologies to address various barriers to effective incident management. Provide motorist assistance or courtesy patrols to clear and identify incidents. TxDOT should not initiate deployment that is not founded on local policy and commitment.

* <u>Emissions Testing and Mitigation</u>

  Provides information for monitoring air quality and developing air quality improvement strategies.

Deployment Scenario: Lead role should be environmental agencies -- in Texas, Texas Natural Resources Conservation Commission (TNRCC). Deployment will progress as cost-effectiveness of technology permits.

Near Term Role for TxDOT: Provide access to communications infrastructure associated with other deployed applications. Coordinate with TNRCC on data standards and handling so that needed planning data can be obtained consistently between agencies.

TRAVEL DEMAND MANAGEMENT

The Travel Demand Management user services support policies and strategies that are aimed at reducing vehicle demand by developing and encouraging modes of travel other than the single occupant vehicle. The services in this bundle are designed to increase the use of high occupancy vehicles and transit by providing intermodal information to travelers prior to the beginning of a trip, and by making ridesharing and transit more convenient and easier to use. These services are also aimed at decreasing congestion by altering the timing or location of trips, or eliminating vehicle trips all together.

From a technical perspective, these services rely on information collected and processed by the Travel and Transportation Management services and the Public Transportation Operations services. Travel Demand Management services also interact with the Travel and Transportation Management services in terms of implementing control strategies that can provide incentives, or disincentives, to change travel behavior.

* Demand Management and Operations

Supports policies and regulations designed to mitigate the economic, environmental and social impacts of traffic congestion.

Deployment Scenario: Deployment will need to be tailored to the demand management approaches and policies adopted locally; deployment costs and responsibilities should be examined by all affected agencies as an aspect of demand management policy implementation.

Near Term Role for TxDOT: Coordination with local agencies through MPO. Deployment role will be determined in planning.

*Pre-Trip Travel Information

Provides information for selecting the best transportation mode, departure time, and route.

Deployment Scenario: This service is excellent opportunity for private sector delivery. Several research issues likely to emerge -- what is impact of pre-trip information on traveler behavior? how sensitive is the credibility of pre-trip information?, etc. Effective deployment will require multi-jurisdiction and multi-modal participation and cooperation.

Near Term Role for TxDOT: TxDOT role should be to establish policy framework to facilitate private sector service delivery. That role could include a providing the infrastructure for data collection; managing access to data; establishing standards for information dissemination. TxDOT role will be affected by the policy position of the Department on private sector participation.

* Ride Matching and Reservation

Makes ride sharing easier and more convenient.

Deployment Scenario: Principal deployment role belongs to entities with local ride-matching responsibilities. This service provides an opportunity for enhancing the effectiveness of HOV lanes, park and ride lots, and other demand management facilities.

Near Term Role for TxDOT: Promotion of the available services and coordination in the planning and deployment of required technologies.

PUBLIC TRANSPORTATION OPERATIONS

The Public Transportation Operations bundle reflects the commonality of the transit authority as the most probably provider of these services. The transit authority is responsible for implementing systems that are capable of better managing the public transportation system and providing improved transit and mode choice information.

From a technical perspective, all of these user services will share a common public transit database. The data will be available for all of the services to customize for their specific function. This data will also support services in the Travel and Transportation Management and the Travel Demand Management bundles.

* <u>Public Transportation Management</u>

  Automates operations, planning, and management functions of public transit systems.

Deployment Scenario: Transit agencies in primary deployment role. Coordination required to assure that needed real-time information is accommodated by the ITS infrastructure.

Near Term Role for TxDOT: TxDOT supports transit efforts by incorporating identified communications system capacity into infrastructure planning and by providing access to real-time data and information needed to facilitate transit management activities.

* <u>En-Route Transit Information</u>

  Provides information to travelers using public transportation after they begin their trips.

Deployment Scenario: Transit agencies in primary deployment role. Real-time information from the ITS infrastructure will be needed to support this service.

Near Term Role for TxDOT: TxDOT supports transit efforts by incorporating identified communications system capacity into infrastructure planning and by providing access to real-time data and information needed to provide en-route information. Coordination of data collection system design will be critical to assure appropriate information is available.

* <u>Personalized Public Transit</u>

  Provides flexibly-routed transit vehicles to offer more convenient customer service.

Deployment Scenario: Transit agencies in primary deployment role. On-line models to support personalized service may provide analysis useful to other agencies or other en-route travel advisories.

Near Term Role for TxDOT: TxDOT supports transit efforts by anticipating communications system capacity needs in infrastructure planning and by making appropriate system data available, as needed.

* Public Travel Security

Creates a secure environment for public transportation patrons and operators.

Deployment Scenario: Transit agencies in primary deployment role.

Near Term Role for TxDOT: TxDOT supports transit efforts by incorporating identified communications system capacity needs into infrastructure planning. Where video surveillance is deployed for traffic management activities, TxDOT and transit agencies should examine possibilities for expanding the use of video for patron security at roadside locations, such as bus stops and park and ride lots.

ELECTRONIC PAYMENT

While this bundle contains only one user service, it supports deployment of many other services, both within and outside the transportation arena. This service will be developed, deployed, and operated by both public and private organizations.

* Electronic Payment Services

Allows travelers to pay for transportation services, including transit, park-and-ride, and tolls, electronically.

Deployment Scenario: Combined local efforts necessary to provide maximum range of services.

Deployment leadership determined by entity with potential constituent demand for services.

Near Term Role for TxDOT: Leadership in assuring interoperability among regions and modes by promulgating national compatibility standards for vehicle-to-roadside communications for both toll and free roads.

COMMERCIAL VEHICLE OPERATIONS

These user services support the goals of improving the efficiency and safety of commercial fleet operations, and will benefit both the States and the motor carrier industry. Thus, the CVO bundle reflects the commonality of using advanced computer and communications technologies to improve the safety and productivity of the motor carrier industry throughout North America.

From a technical perspective, the foundation for all of the CVO user services is information systems. Each service will require some set of information on the motor carrier, the vehicle, the driver, and, in some cases, the cargo. The services are interrelated in terms of the specific types and functionality of information and data required. This network of information will be accessible by States and motor carriers nationwide.

* <u>Commercial Vehicle Electronic Clearance</u>

  Facilitates domestic and international border clearance, minimizing stops.

Deployment Scenario: Partnership between carriers, TxDOT and law enforcement (DPS) necessary to achieve meaningful deployment. Commercial vehicle operators will have significant technology deployment role.

Near Term Role for TxDOT: Primarily leadership role in the planning for both electronic clearance and management of cleared vehicles. This function interacts with others, especially traffic control. Another significant role will be in the research of technologies and practices necessary to achieve automated enforcement (weight, height, credentials, etc.) and to enhance the current permitting process.

* <u>Automated Roadside Safety Inspection</u>

  Facilities roadside inspections.

Deployment Scenario: Partnership among carriers, TxDOT and DPS. This service should be examined in concert with the Electronic Clearance service above, in that there are significant opportunities to maximize the effectiveness and efficiencies of on-board as well as roadside systems.

Near Term Role for TxDOT: Partnership with Department of Public Safety and commercial vehicle operators in planning of sites and infrastructure. Numerous research issues likely to emerge.

* <u>On-Board Safety Monitoring</u>

  Senses the safety status of a commercial vehicle, cargo, and driver.

Deployment Scenario: Primary activity is R&D by USDOT. Eventual deployment, probably beyond the five-year horizon of this analysis, will likely be focused on individual carriers that opt to participate.

Near Term Role for TxDOT: Maintain awareness of potential deployment by carriers.

* <u>Commercial Vehicle Administrative Processes</u>

Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.

Deployment Scenario: To be deployed primarily by commercial vehicle operators.

Near Term Role for TxDOT: There may be opportunities to jointly share communications infrastructure. TxDOT role would be to assure capacity and capability to accommodate this service. This service could offer the potential to streamline electronic processing of permits to enhance the efficiency provided in Commercial Vehicle Electronic Clearance.

* <u>Hazardous Material Incident Response</u>

Provides immediate description of hazardous materials to emergency responders.

Deployment Scenario: This service will likely be deployed by state and local emergency agencies. Technologies are not sufficiently mature at this time to establish whether deployment can be realistically expected in the near term.

Near Term Role for TxDOT: Assure communications system capacity and capability to accommodate this service. Could be an opportunity to link mapping, dynamic routing and real-time information capabilities to emergency agencies for improved response.

* <u>Commercial Fleet Management</u>

Provides communication between drivers, dispatchers, and intermodal transportation providers.

Deployment Scenario: Fleet operators will be primary deployment agents.

Near Term Role for TxDOT: Provide opportunity for commercial ventures to access real-time system condition information.

EMERGENCY MANAGEMENT

Police, fire and rescue operations can use emergency management services to improve their management of and response to emergency situations. These user services have common functional elements such as vehicle location, communications, and response.

* <u>Emergency Notification and Personal Security</u>

Provides immediate notification of an incident and an immediate request for assistance.

Deployment Scenario: Primarily consumer products to be offered by private sector as markets demand.

Near Term Role for TxDOT: Limited role as currently envisioned. Some potential for using distress signals as additional input for incident identification.

* Emergency Vehicle Management

Reduces the time it takes for emergency vehicles to respond to an incident.

Deployment Scenario: Local entities and DPS have primary deployment role.

Near Term Role for TxDOT: Partnership with emergency agencies to facilitate movement and deployment strategies of emergency vehicles. These strategies include coordination with signal systems operated by TxDOT and others, coordination with rail-highway grade crossing activity, development of priority treatments for emergency vehicles.

ADVANCED VEHICLE CONTROL AND SAFETY SYSTEMS

Although each of these services addresses a separate function, they all contribute to the common goal of improving vehicle safety. With the exception of Automated Highway Systems (AHS), all of these user services are characterized by near-term reliance on self-contained systems within the vehicle. The functionality of these user services, however, can be enhanced by supplementing the on-board capabilities with additional sensors deployed in the infrastructure.

Within the vehicle, common functional elements, such as data storage, processing units, sensors, or actuators, could be shared among the user services in this bundle, including AHS.

* Longitudinal Collision Avoidance

Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Lateral Collision Avoidance

Helps prevent collisions when vehicles leave their lane of travel.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Intersection Collision Avoidance

  Helps prevent collisions at intersections.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Vision Enhancement for Crash Avoidance

  Improves the driver's ability to see the roadway and objects that are on or along the roadway.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Safety Readiness

  Provides warnings about the condition of the driver, the vehicle, and the roadway.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Pre-Crash Restraint Deployment

  Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

* Automated Highway Systems

  Provides a fully automated, "hands-off," operating environment.

Near Term Role for TxDOT: Maintain awareness of technological advances in order to facilitate public education/information and to be prepared for appropriate linking role.

APPENDIX C

Core Infrastructure Features for ITS Deployment in Metropolitan Areas

Core Infrastructure Features for ITS Deployment in Metropolitan Areas

Purpose

This paper presents definitions for a set of seven features which form the "core infrastructure" for deploying Intelligent Transportation System (ITS) traffic management and traveler information services in a metropolitan area. These definitions constitute today's "state-of-the-art" implementation of ITS, which will establish a foundation for deployment of future ITS user services to be provided by both public and private sector entities. By developing and circulating these definitions, the US DOT intends to focus near-term deployment decisions being made in metropolitan areas, and to maximize future opportunities to implement widespread, advanced ITS user services. Establishment of the core infrastructure features permits optimal operations and management of roadway and transit resources through use of currently-available technologies and strengthened institutional ties. In the near-term, implementation of the core infrastructure features is expected to be lead by the public sector, and development of these capabilities is expected to occur in an evolutionary manner. However, private sector participation is highly encouraged, and appropriate partnership opportunities should be actively sought by State and local implementing agencies. Maturation of the core features in a number of metropolitan areas can be expected to drive private sector development of products and industries to provide future ITS user services.

This paper defines metropolitan area core infrastructure as consisting of seven features. These are:

1. Regional Multimodal Traveler Information Center
2. Traffic Signal Control System(s)
3. Freeway Management System(s)
4. Transit Management System(s)
5. Incident Management Program
6. Electronic Fare Payment System(s)
7. Electronic Toll Collection System(s)

Note that the requirements for a number of ITS user services, such as those relating to commercial vehicle operations and vehicle safety systems, are not included in this document since they do not directly relate to metropolitan ITS user services.

Principles Guiding Definitions

In defining these core infrastructure features, the following principles were followed:

Deployment of the feature(s) will enable meaningful implementation of metropolitan-area ITS user services and facilitate deployment of many other ITS user services.

Each feature could be deployed independently of the others, but concurrent implementation would significantly increase overall benefits and/or decrease incremental costs. The feature(s) can be readily deployed in the near term using "state-of-the-art" concepts and technologies (versus existing "state-of-the-practice"), and typically would be eligible for Federal-aid funding. Varying technologies, from "low-tech" to "high-tech," can be used to deploy/implement each feature.

The definitions should account for different institutional environments, varying spacial/geographic relationships among centers of activity (i.e., as with CBD / ring city / suburb relationship), and recognize that system(s) will evolve over time to provide for greater benefits/lower costs.

Private sector participation in delivering ITS user services will be encouraged to the maximum extent possible, particularly in the collection and dissemination of traveler information. The private sector is also encouraged to participate in development of the core features.

Key Considerations for Deployment of the Core Infrastructure

Based on analysis of the unique needs in a specific area, metropolitan regions usually will pursue implementation of some combination of the core features, eventually leading to a comprehensive ITS. This expected parallel deployment of features is supported to a large degree by common physical(hardware/software) components and institutional relationships which contribute to successful implementation of more than one core feature. These key fundamentals include:

Capability to distribute multimodal traveler information to the general traveling public,

Surveillance and detection capability; resulting in current, comprehensive, and accurate traffic and transit system performance information,

Infrastructure-based communications systems linking field equipment with central software/database systems,

Communications (routine information sharing) among jurisdictions, between traffic and transit agencies, and between the public and private sectors; without necessarily relinquishing control responsibility (i.e., "share information but not control") -- This may entail formal interagency agreements for incident response and information sharing,

Information sharing/coordination with emergency medical services, hazardous materials programs, and other appropriate participants,

Proactive management of roadway and transit resources to achieve metropolitan transportation objectives,

Sufficient resources for continuing support of system operations and maintenance needs, including personnel and training requirements.

Several of the above points highlight coordination among jurisdictions and agencies within a metropolitan area. The typical metropolitan area transportation system is managed by a diverse set of State and local-level entities, and movement toward implementation of core infrastructure features will occur at different institutional rates. While it is important for individual institutions/jurisdictions to analyze deployment initiatives to meet their specific needs, many advanced ITS services require wide-scale coordination across jurisdictional boundaries. Where these area-wide approaches are envisioned, enhanced communication and coordination of project development concepts, system architectures, interface standards, design/construction schedules, and operations/maintenance responsibilities and resources are crucial.

In addition to metropolitan-specific deployment, these core infrastructure features can form the basis for further deployment of related ITS user services in the national transportation network. This growth may be focussed especially on major intercity arterials which are part of the National Highway System. Through appropriate coordination in program development, the core infrastructure features can support an integrated approach to ITS services such as commercial vehicle systems deployments in major truck network routes, electronic toll and traffic management systems beyond urban areas, and various services along suburban/rural corridors. National compatibility efforts, including application of the emerging national ITS system architecture, will preserve the capability for future expansion, innovation, and advancement of the ITS program.

Definitions of ITS Core Infrastructure Features.

1. Regional Multimodal Traveler Information Center.

The metropolitan area has a repository of current, comprehensive, and accurate roadway and transit performance data. Potential customers and information providers include individuals, business travelers, private sector firms for which transportation service is critical to success, value-added resellers of the information, and public sector entities responsible for transportation system operation and/or safety. Sufficient data is received to provide for ITS user services such as pre-trip and en-route traveler information, such that informed choices regarding mode, route, and time-of-travel can be made by customers.

This repository, either a single physical facility or an inter-connected set of facilities, directly receives roadway and transit system surveillance and detection information from a variety of sources provided by both the public and private sector entities. To a large degree, these sources (and recipients) of information are the other core infrastructure features. The RMTIC has the capability to combine data from varying sources, package the data in various formats, and provide the information to a variety of distribution channels, including voice or computer services, radio broadcasts, kiosks, etc.

Among the core infrastructure features, the RMTIC is the key feature which provides a bridge between the general public and the transportation system managers. Through linking data from the other features into a comprehensive regional information system, deployment of these Centers will exemplify movement toward advanced ITS user services. Since these RMTIC's do not currently exist and need to be created in most metropolitan areas, compatibility with the emerging ITS system architecture is essential to assure national interoperability and compatibility.

2. Traffic Signal Control System(s).

Signal control system(s) have the capability to adjust the amount of green time for each street and coordinate operation between each signal to maximize the person and vehicular throughput and minimize delay through appropriate response to changes in demand patterns. At a minimum, these coordinated system(s) will provide for a selection of "time-of-day" signal timing patterns which optimize operations along major arterial routes and throughout signal networks. The capability to adjust the traffic signal timing may include computer-generated timing plans and/or manual operation by a skilled and knowledgeable operator. The hardware/software system(s) are designed to be upgraded incapability as required for future operations with an "open architecture" which enables relatively inexpensive and efficient installation of improved products, and potential coordinated operations with adjacent freeway and arterial systems.

The various jurisdictional systems are capable of electronically sharing traffic flow data with the signal systems of adjoining jurisdictions in order to provide metropolitan-wide signal coordination.

3. Freeway Management System(s).

The freeway traffic managers in a metropolitan area have the capability to monitor traffic conditions on the freeway system; identify recurring and non-recurring flow impediments; implement appropriate control and management strategies (such as ramp metering and/or lane control); and provide critical information to travelers through infrastructure-based dissemination methods, such as variable message signs and highway advisory radio.

The freeway management system(s) includes a Freeway Management Center (or multiple centers where responsibility for the freeway system is shared by more than one jurisdiction) and information links to the multimodal traveler information center and other management and control systems in the metropolitan area. These capabilities can encompass and/or expand to provide for coordination of response to emergency and special-event situations. Examples of proactive management include regular analysis and updating of control strategies, and provision of adequate operations and maintenance resources to support the system's operational objectives.

4. Transit Management System(s).

The transit system(s) in the metropolitan area have implemented fleet management system(s), including hardware/software components on buses and in dispatching centers, software, available radio communications spectrum, operator training, and maintenance. Depending upon needs, the fleet management system(s) would utilize automatic vehicle location, include advanced voice and data communications, automatic passenger counting, driver information (voice and visual), vehicle diagnostics, linkage to geographic information systems, and computer-aided dispatching.

The system provides reliable bus position information to the dispatcher. The dispatcher or a central computer compares the actual location with the scheduled location, enabling positive action to improve schedule adherence and expanded information for transmission to the RMTIC and for direct customer information. In addition, on-board sensors automatically monitor data such as vehicle passenger loading, fare collection, drive-line operating conditions, etc.; providing for real-time management response. In the event of an on-board emergency, the dispatcher can inform the police of the emergency situation and direct them to the vehicle's exact location.

5. Incident Management Program.

The metropolitan area has an organized and functioning system for quickly identifying and removing incidents that occur on area freeways and major arterials. The roadway is cleared and flow restored as rapidly as possible, minimizing frustration and delay to the traveling public while at the same time meeting the requirements and responsibilities of the agencies and individuals involved.

The various jurisdictions and agencies responsible for operations and enforcement in the metropolitan area have worked together to develop a policy and operations agreement which defines specific responsibilities for all features of incident management, including detection, verification, response, clearance, scene management, and traffic management and information. This multi-jurisdictional operating agreement ensures routine cooperation, coordination and communication among all agencies; including enforcement, fire, ambulance, highway traffic control and maintenance, environmental and other public agencies. In addition, private sector participants such as the towing and recovery industry may be involved in clearance.

6. Electronic Fare Payment System(s).

An electronic payment system is in operation within the metropolitan area for transit fares. The system(s) include hardware and software for roadside, in-vehicle, and in-station use; and passenger/driver payment cards, possibly with software, financial and card accounting system(s). Electronic fare collection eliminates the need for customers to provide exact change and facilitates the potential creation of a single fare medium for all public transportation services.

The system(s) could include both debit and credit capability; although stored-value capability is a requirement, and cash would also be accepted. Where appropriate, the system(s) would facilitate the participation of employers in transit benefit programs where employers pay for their employees transit accounts which are debited only for work trips.

7. Electronic Toll Collection System(s).

An electronic payment system is in operation within or around the metropolitan area for toll collection. The system(s) include hardware and software for roadside and in-vehicle use; driver payment cards or tags, possibly with software, financial and card accounting system(s); and a communications system between vehicles and the roadside. Electronic toll collection (ETC) will allow drivers to pay tolls without stopping, thus decreasing delays and improving system productivity.

The system(s) could include any combination of debit, credit or stored value capability. ETC systems could be installed in various configurations, including mainline barrier plazas and systems where tolls are based on entry and exit points. Specific components of the system(s) are expected to include automatic vehicle identification, automatic determination of tolls for differing classes of vehicles, automated enforcement of violations and flexibility in financial arrangement.

APPENDIX D

ITS User Services Definitions

ITS USER SERVICES DEFINITIONS

1.0 INTRODUCTION

The National ITS program is focused on the development and deployment of a collection of inter-related user services. Twenty-nine user services have been defined to date as part of the national program planning process. This list of user services is neither exhaustive nor final. There is a wide array of transportation services that could develop that are not included in this list. In addition, the services here are expected to change over time. Some will develop largely as envisioned. New services will emerge, and others, for various reasons, will never be developed. This list of services, and the accompanying descriptions are expected to evolve through program plan updates and new editions.

The users of these services include travelers using all modes of transportation, transportation management center operators, transit operators, Metropolitan Planning Organizations (MPOs), commercial vehicle owners and operators, state and local governments, and many others who will benefit from deployment of ITS. Detailed plans for each user service are provided in Volume II of the NPP.

2.0 USER SERVICE DESCRIPTIONS

Although each user service is unique, they share common characteristics and features as described below.

* **Individual user services are building blocks** that may be combined for deployment in a variety of fashions. The combination of services deployed will vary depending upon local priorities, needs and market forces. Within the National ITS Program Plan (NPP), user services have been grouped into "bundles" based on likely deployment scenarios as described later in this chapter and in Chapter V, User Services Integration.

* **User services comprise multiple technological elements or functions** which may be common with other services. For example, a single user service will usually require several technologies, such as advanced communications, mapping, and surveillance, which may be shared with other user services. This commonality of technological functions is one basis for the suggested bundling of services.

* **User services are in various stages of development** and will be deployed as systems according to different schedules. Some of the technologies required by various user services are currently available in the marketplace, while others will require significant research and development before they can be deployed. The development and deployment of an individual service will be guided by the policies and priorities established by both the public and private sector participants. These policies and priorities will evolve based on changing technologies,

economic factors, and market conditions.

* **Costs and benefits of user services depend upon deployment scenarios.** Once the basic technological functions, such as communications or surveillance, have been deployed for one user service, the additional functions needed by one or more related services may require only a small incremental cost to produce additional, often significant, benefits.

* **Many user services can be deployed in rural, suburban and/or urban settings.** User services are not specific to a particular location. Rather, the function of the service can be adapted to meet local needs and conditions.

3.0 USER SERVICE BUNDLING

Although it may be possible to deploy a system that provides a single user service, in many cases, services are more likely to be deployed in combination with other services or *"bundle"* which share some commonality.

For purposes of discussion in the NPP, the twenty-nine user services have been sorted into categories termed "bundles." The services within these bundles may be related in a number of different ways. In some cases, the institutional perspectives of organizations that will deploy the services provide the rationale for the formation of a specific bundle. Other bundles were organized around common technical functionalities. These services could have been bundled in any number of ways. Table 3-1 presents only one of a number of possibilities. When the services are actually deployed, it is likely that services will also be mixed and matched among the bundles, as well as within a single bundle.

3.1 Travel and Transportation Management

The Travel and Transportation Management user services were grouped in a single bundle because of the information they share about the surface transportation system. These services collect and process information about the surface transportation system, and provide commands to various traffic control devices. Travel management services disseminate this information to the traveler. When used in concert, these services can provide a comprehensive travel and transportation management system. These services also provide information to support the Travel Demand Management and the Public Transportation Operations bundles. Thus, the Travel and Transportation Management bundle will be of interest to transportation policy makers, public and private sector operators of transportation management centers, those involved in incident response or travel demand management, and private sector vendors supplying travel information products and services.

* En-Route Driver Information

  Provides driver advisories and in-vehicle signing for convenience and safety.

  Driver advisories are similar to pre-trip planning information, but they are provided once travel begins. Driver advisories convey real-time information about traffic conditions, incidents, construction, transit schedules, and weather conditions to drivers of personal, commercial and public transit vehicles. This information allows a driver to either select the best route, or shift to another mode in mid-trip if desired.

  In-vehicle signing, the second component of en-route driver information, provides the same types of information found on physical road signs today, directly in the vehicle. The service could be extended to include warnings of road conditions and safe speeds for specific types of vehicles, such as autos, buses, and large trucks, but potential users include drivers of all types of vehicles. This service might be especially useful to elderly drivers, in rural areas with large numbers of tourists, or in areas with unusual or hazardous roadway conditions.

* Route Guidance

  Provides travelers with simple instructions on how to best reach their destinations.

  The route guidance service provides a suggested route to reach a specified destination. Early route guidance systems are based on static information about the roadway network or transit schedules. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route guidance service will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route. Directions will generally consist of simple instructions on turns or other upcoming maneuvers. Users of the service include not only drivers of all types of vehicles, but also non-vehicular travelers, such as pedestrians or bicyclists, who could get specialized route guidance from a hand-held device.

* Traveler Services Information

  Provides a business directory, or "yellow pages," of service information.

  Traveler services information provides quick access to travel-related services and facilities. Examples of information that might be included are the location, operating hours, and availability of food, lodging, parking, auto repair, hospitals, and police facilities. Traveler services information would be accessible in the home, office or other public locations to plan trips, and would also be available en-route. When fully deployed, this service will connect users and providers interactively to request and provide needed information. A comprehensive, integrated service could support financial transactions, such as automatic billing for purchases.

* Traffic Control

Manages the movement of traffic on streets and highways.

The traffic control user service provides for the integration and adaptive control of the freeway and surface street systems to improve the flow of traffic, give preference to public safety, transit or other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. Through appropriate traffic controls, the service also promotes the safety of non-vehicular travelers, such as pedestrians and bicyclists. It requires advanced surveillance of traffic flows, analysis techniques for determining appropriate traffic signal and ramp metering controls, and communication of these controls to the roadside infrastructure. This service gathers data from the transportation system and organizes it into usable information to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the Traffic Control services also provides the foundation for many other user services.

* Incident Management

Helps public and private organizations to quickly identify incidents and implement a response to minimize their effects on traffic.

The Incident Management service uses advanced sensors, data processing, and communications to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response. The service will enhance existing incident detection and verification capabilities to help these groups quickly and accurately identify a variety of incidents and implement a response. The improved response time will minimize the effects of these incidents on the movement of people and goods. This service will also help transportation officials predict traffic or highway conditions so that they can take action in advance to prevent potential incidents or minimize their impacts. While the direct users of this service are the public and private entities responsible for incident detection and response, the ultimate beneficiaries are commercial and transit operators, and the traveling public.

* Emissions Testing and Mitigation

Provides information for monitoring air quality and developing air quality improvement strategies.

The Emissions Testing and Mitigation service uses advanced vehicle emissions testing systems to provide information to identify environmental "hot spots" and implement strategies to either reroute traffic around sensitive air quality areas or control access to such areas. Other technologies provide identification of vehicles that are emitting levels of pollutants that exceed state, local or regional standards, and provide information to drivers or fleet operators to enable them to take corrective action. The service also provides transportation planning and operating agencies with information that can be used to facilitate implementation and evaluation on various pollution control strategies.

3.2 Travel Demand Management

The Travel Demand Management user services support policies and strategies that are aimed at reducing vehicle demand by developing and encouraging modes of travel other than the single occupant vehicle. The services in this bundle are designed to increase the use of high occupancy vehicles and transit by providing intermodal information to travelers prior to the beginning of a trip, and by making ride sharing and transit more convenient and easier to use. These services are also aimed at decreasing congestion by altering the timing or location of trips, or eliminating vehicle trips all together.

From a technical perspective, these services rely on information collected and processed by the Travel and Transportation Management services and the Public Transportation Operations services. Travel Demand Management services also interact with the Travel and Transportation Management services in terms of implementing control strategies that can provide incentives, or disincentives, to change travel behavior.

* Demand Management and Operations

  Supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.

  The Demand Management and Operations service generates and communicates management and control strategies that support the implementation of programs to reduce the number of individuals who choose to drive alone, especially to work; increase the use of high occupancy vehicles, transit, and commuter rail; and provide a variety of mobility options for those who wish to travel in a more efficient manner, for example in non-peak periods. Demand management strategies could ultimately be applied dynamically, when congestion or pollution conditions warrant. For example, disincentives such as increased tolls and parking fees could be applied during pollution alerts or peak travel periods, while transit fares would be lowered to accommodate the increased number of travelers changing modes from driving alone. Such strategies will reduce the negative impacts of traffic congestion on the environment and improve overall quality of life.

* Pre-Trip Travel Information

  Provides information for selecting the best transportation mode, departure time, and route.

  Pre-trip travel information allows travelers to access a complete range of intermodal transportation information at home, work, and other major sites where trips originate. Real-time information on transit and commuter rail routes, schedules, transfers, fares, and ride matching services are available to encourage the use of alternatives to the single occupancy vehicle. Information needed for long, inter-urban or vacation trips would also be available. Real-time information on accidents, road construction, alternate routes, traffic speeds along given routes, parking conditions, event schedules, and weather information is also included. Based on this information, the traveler can select the best route, modes of travel and departure time, or decide not to make the trip at all.

* Ride Matching and Reservation

  Makes ride sharing easier and more convenient.

  The Ride Matching and Reservation service provides real-time ride matching information and reservations to users in their homes, offices or other locations, and assist transportation providers, as well as van/carpoolers, with vehicle assignments and scheduling. This will expand the market for ridesharing as an alternative to single occupant vehicle travel and will provide for enhanced alternatives for special population groups, such as the elderly or the handicapped.

3.3 Public Transportation Operations

The Public Transportation Operations bundle reflects the commonality of the transit authority as the most probably provider of these services. The transit authority is responsible for implementing systems that are capable of better managing the public transportation system and providing improved transit and mode choice information.

From a technical perspective, all of these user services will share a common public transit database. The data will be available for all of the services to customize for their specific function. This data will also support services in the travel and Transportation Management and the Travel Demand Management bundles.

* Public Transportation Management

  Automates operations, planning, and management functions of public transit systems.

  The Public Transportation Management service provides computer analysis of real-time vehicle and facility status to improve transit operations and maintenance. The analysis identifies deviations from schedules and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure transfer connections in intermodal transportation. Information regarding passenger loading, bus running times, and mileage accumulated will help improve service and facilitate administrative reporting. Transit personnel management is enhanced by automatically recording and verifying tasks performed by transit personnel.

* En-Route Transit Information

  Provides information to travelers using public transportation after they begin their trips.

  The En-Route Transit Information service provides information to assist the traveler once public transportation travel begins. Real-time, accurate transit service information on-board the vehicle helps travelers make effective transfer decisions and itinerary modifications as needed while a trip is underway.

* Personalized Public Transit

  Provides flexibly-routed transit vehicles to offer more convenient customer service.

  Small publicly or privately-operated vehicles provide on-demand routing to pick up passengers who have requested service and deliver them to their destinations. Route deviation schemes, in which vehicles leave a fixed route for a short distance to pick up or discharge passengers, is another way of improving service. Vehicles can include small buses, taxicabs, or other small, shared ride vehicles. This service can provide almost door-to-door service, expanding transit coverage to lesser populated locations and neighborhoods. Potentially, this service can provide transportation at lower cost and with greater convenience than conventional fixed route transit.

* Public Travel Security

  Creates a secure environment for public transportation patrons and operators.

  This service provides systems that monitor the environment in transportation stations, parking lots, bus stops, and on-board transit vehicles, and generate alarms, either automatically or manually, when necessary. This improves security for both transit riders and operators. Transportation agencies and authorities can integrate this user service with other anti-crime activities.

3.4 Electronic Payment

While this bundle contains only one user service, it supports deployment of many other services, both within and outside the transportation arena. This service will be developed, deployed, and operated by both public and private organizations.

* Electronic Payment Services

  Allows travelers to pay for transportation services electronically.

  Electronic Payment services will foster intermodal travel by providing a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. The service provides for a common service fee and payment structure using "smart cards" or other technologies. Such systems could be expanded to become truly multi-use, accommodating personal financial transactions that are made with today's credit/bank cards. The flexibility that electronic payment services offer will also facilitate travel demand management, if conditions warrant. They could, if local authorities so choose, enable application of road pricing policies which could influence departure times and mode selection.

3.5 Commercial Vehicle Operations

These user services support the goals of improving the efficiency and safety of commercial fleet operations, and will benefit both the States and the motor carrier industry. Thus, the CVO bundle reflects the commonality of using advanced computer and communications technologies to improve the safety and productivity of the motor carrier industry throughout North America.

From a technical perspective, the foundation for all of the CVO user services is information systems. Each service will require some set of information on the motor carrier, the vehicle, the driver, and, in some cases, the cargo. The services are interrelated in terms of the specific types and functionality of information and data required. This network of information will be accessible by States and motor carriers nationwide.

* Commercial Vehicle Electronic Clearance

  Facilitates domestic and international border clearance, minimizing stops.

  This service will enable transponder-equipped trucks and buses to have their safety status, credentials, and weight checked at mainline speeds. Vehicles that are safe and legal and have no outstanding out-of-service citations will be allowed to pass the inspection/weigh facility without delay.

  By working with Mexico and Canada, a more efficient traffic flow would be provided at border crossings. The deployment of technologies in these countries could ultimately prevent overweight, unsafe, or improperly registered vehicles from entering the United States.

* Automated Roadside Safety Inspection

  Facilities roadside inspections.

  Automated roadside inspections would allow real-time access at the roadside to the safety performance record of carriers, vehicles, and drivers. Such access will help determine which vehicle or driver should be stopped for an inspection, as well as ensuring timely correction of previously identified problems.

  This service would also automate as many items as possible of the manual inspection process.

It would, for example, allow for more rapid and accurate inspection of brake performance at the roadside. Through the use of sensors and diagnostics, it would efficiently check vehicle systems and driver requirements and ultimately driver alertness and fitness for duty.

* On-Board Safety Monitoring

Senses the safety status of a commercial vehicle, cargo, and driver.

On-board systems would monitor the safety status of a vehicle, cargo, and driver at mainline speeds. Vehicle monitoring would include sensing and collecting data on the condition of critical vehicle components such as brakes, tires, and lights, and determining thresholds for warnings and countermeasures. Cargo monitoring would involve sensing unsafe conditions relating to vehicle cargo, such as shifts in cargo while the vehicle is in operation. Driver monitoring is envisioned to include the monitoring of driving time and alertness using non-intrusive technology and the development of warning systems for the driver, the carrier, and the enforcement official. A warning of unsafe condition would first be provided to the driver and then to the carrier and roadside enforcement officials. This warning notification would possibly prevent an accident from happening. This service would minimize driver-and equipment-related accidents for participating carriers.

* Commercial Vehicle Administrative Processes

Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.

The Commercial Vehicle Administrative Processes service provides the commercial carrier with the capability to electronically purchase annual and temporary credentials via a computer link. It will reduce burdensome paperwork and processing time for both the State agencies and the motor carriers.

For automated mileage and fuel reporting and auditing, this service enables participating interstate carriers to electronically capture mileage, fuel purchased, trip, and vehicle data according to state. It would also automatically determine mileage traveled and fuel purchased in each state, for use by the carrier in preparing fuel tax and registration reports to the State agencies. This service would reduce the significant administrative burden on commercial carriers to collect and report mileage and fuel purchased within each State.

* Hazardous Material Incident Response

Provides immediate description of hazardous materials to emergency responders.

The Hazardous Material Incident Response service enhances the safety of shipments of hazardous materials by providing enforcement and response teams with timely, accurate information on cargo contents to enable them to react properly in emergency situations. The materials or combination of materials involved when an incident involving a truck or railcar carrying hazardous material occurs would be provided electronically to emergency responders and enforcement personnel at the scene so that the incident can be handled properly.

* Commercial Fleet Management

  Provides communication between drivers, dispatchers, and intermodal transportation providers.

  The Commercial Fleet management service provides real-time traffic information and vehicle location for commercial vehicles. This service significantly enhances fleet operations management by helping drivers to avoid congested areas and improving the reliability and efficiency of pickups and deliveries. These benefits are particularly important for operators of intermodal and time-sensitive fleets who can use this ITS service to make their operations more efficient and reliable.

3.6 Emergency Management

Policy, fire and rescue operations can use emergency management services to improve their management of and response to emergency situations. These user services have common functional elements such as vehicle location, communications, and response.

* Emergency Notification and Personal Security

  Provides immediate notification of an incident and an immediate request for assistance.

  The Emergency Notification and Personal Security service include two capabilities: driver and personal security, and automatic collision notification. Driver and personal security capabilities provide for user-initiated distress signals for incidents such as mechanical breakdowns or car-jackings. When activated by an incident, automatic collision notification transmits information regarding location, nature, and severity of the crash to emergency personnel.

* Emergency Vehicle Management

  Reduces the time it takes for emergency vehicles to respond to an incident.

  The Emergency Vehicle Management service provides public safety agencies with fleet management capabilities, route guidance, and signal priority and/or preemption for emergency vehicles. Fleet management improves the display of emergency vehicle locations and helps dispatchers send the units that can most quickly reach an incident site. Route guidance directs emergency vehicles to an incident location and signal priority optimizes the traffic signal timing in an emergency vehicle's route. Primary users of this service include policy, fire, and medical units.

3.7 Advanced Vehicle Control and Safety Systems

Although each of these services addresses a separate function, they all contribute to the common goal of improving vehicle safety. With the exception of Automated Highway Systems (AHS), all of these user services are characterized by near-term reliance on self-contained systems within the vehicle. The functionality of these user services, however, can be enhanced by supplementing the on-board capabilities with additional sensors deployed in the infrastructure.

Within the vehicle, common functional elements, such as data storage, processing units, sensors, or actuators, could be shared among the user services in this bundle, including AHS.

* Longitudinal Collision Avoidance

  Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.

  The Longitudinal Collision Avoidance service helps reduce the number and severity of longitudinal collisions, such as head-on, rear-end or backing. It includes the sensing of potential or impending collisions, prompting a driver's avoidance actions, and controlling the vehicle temporarily.

* Lateral Collision Avoidance

  Helps prevent collisions when vehicles leave their lane of travel.

  The Lateral Collision Avoidance service provides crash warnings and controls for lane changes and road departures. It will reduce the number of lateral collisions involving two or more vehicles, as well as crashes involving a single vehicle leaving the roadway. For changing lanes, a situation display can monitor the vehicle's blind spot continuously, and drivers can be actively warned of an impending collision. If needed, automatic control can provide rapid response to a situation. Warning systems can also alert a driver to an impending road departure, provide help in keeping the vehicle in the lane, and ultimately provide automatic control of steering throttle.

* Intersection Collision Avoidance

  Helps prevent collisions at intersections.

  The Intersection Collision Avoidance service warns drivers of imminent collisions when approaching or crossing an intersection or railroad grade crossing that has traffic control (e.g., stop signs or a signal). This service also alerts the driver when the proper right-of-way at the intersection or grade crossing is unclear or ambiguous.

* Vision Enhancement for Crash Avoidance

Improves the driver's ability to see the roadway and objects that are on or along the roadway.

The Vision Enhancement service provides drivers with improved visibility to allow them to avoid collisions with other vehicles, obstacles in the roadway, or parked or moving trains, as well as help them comply with traffic signs and signals. This service requires in-vehicle equipment for sensing potential hazards, processing this information, and displaying it in a way that is useful to a driver.

* Safety Readiness

Provides warnings about the condition of the driver, the vehicle, and the roadway.

Safety Readiness services provide in-vehicle equipment that unobtrusively monitors a driver's condition and provides a warning if the driver is becoming drowsy or otherwise impaired. This service could also monitor critical components of the automobile internally and alert the driver to impending malfunctions. Equipment within the vehicle could also detect unsafe road conditions, such as bridge icing or standing water on the roadway, and provide a warning to the driver.

* Pre-Crash Restraint Deployment

Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.

The Pre-Crash Restraint Deployment service anticipates an imminent collision by determining the velocity, mass, and direction of the vehicles or objects involved in a potential crash. The service activates safety systems in the vehicle prior to a collision, such as tightening lap-shoulder belts, arming and deploying air bags at the optimal pressure, and deploying roll bars. The response is based on the number, location, and major physical characteristics of any occupants.

* Automated Highway Systems

Provides a fully automated, "hands-off," operating environment.

AHS is a long-term goal of ITS which would provide vast improvements in safety by creating a nearly accident-free driving environment. In AHS, the vehicle is guided automatically rather than by the driver. Driver error is reduced or possibly eliminated with full implementation. Drivers could buy vehicles with the necessary instrumentation or retrofit an existing vehicle.

AHS benefits include increased roadway capacity, enhanced safety, reduced fuel consumption, and reduced emissions.

4.0 USER SERVICE DEVELOPMENT PLANS

Development plans have been generated for each user service. Each User Service Development Plan identifies the needs that the user service is designed to meet, presents an operational concept for how the service might function in its fully deployed state, describes the technologies that the service might use, discusses potential costs and benefits, and provides an assessment of the public and private sector roles in developing and deploying the systems that will provide the service. The User Service Plans identify major issues or barriers that might impact development and deployment and the activities and milestones that must be accomplished to fully develop the service for system deployment.

Features of the User Service Development Plans include:

* **User service development plans address the stated goals of the ITS program** and provide a framework by which user services can be combined, or bundled, into deployable products and services to achieve these goals and objectives.

* **An assessment of the roles of key public and private sector participants** involved in the development and deployment of the service are described in the user service plans.

* However, **the user service development plans do not define development or deployment policies.** The decision to undertake the necessary activities to develop a user service rests with the individual public or private sector entities involved. Similarly, deployment priorities and decisions rest with the responsible deploying entity, private or public sector provider, and the consumer.

* **The user service development plans are intended to be illustrative** without defining or implying a specific system architecture. The operational concepts and technologies described in the User Service Development Plans present a vision of how the services might be deployed, rather than dictating a deployment scenario. Thus, the activities within the development plans do not dictate the use of specific technologies, but simply present the possibilities as they are known currently.

* Similarly, the **user service development plans do not dictate specific future activities,** but are planning tools to guide and coordinate future activities.

* **The user service development plans are dynamic.** They will evolve as technology and experience change both public and private sector perceptions of the possibilities.

* **Unique safety, human factors, and institutional issues** are covered in each user service

development plan. Crosscutting issues are covered in other sections of the NPP.

APPENDIX E

Assumptions for the Core Infrastructure Cost Estimate

Assumptions for the Core Infrastructure Cost Estimate

AUGUST 1995

The following document contains the assumptions necessary to develop representative costs to deploy a core infrastructure of Intelligent Transportation Systems (ITS) strategies. Some elements (i.e., surveillance, communication, emergency vehicle management) do not lend themselves to a one-to-one correspondence with the seven core infrastructure areas but are listed under the most logical areas. To obtain the cost figures, information from systems in Texas, Virginia, Massachusetts, Washington, Georgia, Minnesota, Maryland, Delaware and California was gathered and discussions with experts in the area of traffic management systems were held. In the attached spreadsheet, the cost for deploying various ITS strategies nationwide is also estimated. The costs are a "worst case scenario" (unless otherwise noted) and reflect areas that are assumed to have no existing infrastructure. In this manner, areas with an existing infrastructure may scale back their costs accordingly. The general assumptions for each size (large, medium, and small) of metropolitan system follow.

Before the assumptions are discussed, it should be mentioned that technology for traffic management strategies is in a state of continual advancement. As technological advancements are made, technologies which were once considered state-of-the-art will be considered state-of-the-practice, and competition will adjust the costs accordingly. For example, as the use of non-intrusive detection methods (i.e., video image processing, acoustic detection, infrared technology) increases, the use of pavement loop detectors will decrease. This document represents state-of-the practice technologies (and their associated costs) which could instrument a core infrastructure of ITS technologies if they were procured and deployed in 1995.

DEFINITIONS

Capital costs refer to the one-time procurement cost of the elements.
Operations and Maintenance costs are annual costs associated with operating and maintaining the necessary elements. Personnel costs are listed separately and are not included under O&M. Operations and Maintenance is assumed to be 5% of the capital costs, unless otherwise recorded, and does not include personnel costs. Maintenance work for surveillance, traveler information, communication, and transportation management centers is done by the same operations and maintenance personnel.

LARGE METROPOLITAN SYSTEM

The large metropolitan area will be the size of Detroit, Michigan with 400 miles of freeway assumed. Interchanges are at 1- mile spacings with all ramps metered. There are 4 lanes in each direction on the large metropolitan area's freeways. There are 12 approach lanes for each signalized intersection. There are assumed to be 2500 signalized intersections. Five additional TMCs (6 total) were included in the costs. For the purposes of this document, metropolitan statistical areas with populations over 750,000 were assumed as large.

MEDIUM METROPOLITAN SYSTEM

The medium metropolitan area will be the size of Knoxville, Tennessee with 300 miles of freeway assumed. Interchanges are at 1-mile spacings with all ramps metered. There are 3 lanes in each direction on the medium metropolitan area's freeways. There are 10 approaches per signalized intersection, and 1500 signalized intersections are assumed. Three additional TMCs (4 total) were included in the costs. For the purposes of this document, metropolitan statistical areas with populations between 200,000 - 750,000 were assumed as medium.

SMALL METROPOLITAN SYSTEM

The small area is the size of Cheyenne, Wyoming with 50 miles of freeway assumed. Interchanges are at 2-mile spacings with no ramps metered. There are 2 lanes in each direction on the small freeways. There are 10 approach lanes for each signalized intersection, and 50 signalized intersections are assumed. For the purposes of this document, metropolitan statistical areas with populations between 50,000 - 200,000 were assumed as small.

GENERAL ASSUMPTIONS

- Freeway mileage is given in centerline miles.
- One center each was assumed for traveler information, emergency management, and transit management. In actuality, some areas may co-locate their facilities.

Computers

The elements under computers include video switches, graphical user interfaces, high capacity storage, cable television access, audio interface, computer monitors, video monitors, video cassette recorder and workstations. The costs for the medium, and small, metropolitan areas were scaled down to 0.8 and 0.7, respectively, of the cost of a large system's computer needs.

Software for the various centers is as follows:

Transportation Management Center (Highway Advisory Radio library, traffic management, automated traffic control, HOV management, lane management, CMS library)
Traveler Information Center (route planning, traffic measurement, data fusion)
Transit Management Center (ride share, transit scheduling, dispatch and fleet management)
Emergency Management Center (emergency management, vehicle tracking)

Communications

This includes the communications equipment internal to the facility such as equipment racks, Sonet System, mulitplexers, modems, etc.

Facilities

The facilities costs were based on purchasing as opposed to leasing space. A building of 23,000 square feet was assumed in the costs for a large system. The costs were scaled accordingly to 0.8 for medium and 0.7 for small. Some of the centers may be co-located.

Field Hardware

- CCTV is at every mile of freeway and at 1/10th of the signalized intersections (trouble spots).
- Environmental Sensors detect road conditions (ice, fog, precipitation, pumping stations, tunnel ventilation, etc.)
- HOV Lane Monitoring and control includes the gates and hardware.
- Loop detectors are placed at half-mile spacings on the freeways across all lanes. They are also placed at every approach lane of signalized intersections and at intermediate locations.
- Call boxes are spaced at half-mile intervals in each direction.
- Video image processing (VIPS) is used at 1/10th of the signalized intersections for the large and medium metropolitan areas.
- Fiber-Optic cable costs include trenching, conduit, installation, and cable.
- Kiosk costs widely vary, depending on the level of integration with various transportation modes, the level of security required, and the type of installation (wall-mounted, free-standing, indoor, outdoor). A mid-range system was assumed. Capital costs include procurement of the kiosks, alarms, software adjustments, technical assistance. Annual costs include kiosk and software maintenance, training, leased dedicated phone lines, supplies, and software license fees.

Incident Management Equipment

The vehicles mentioned in this section are pick-up trucks which have the materials necessary to change tires, direct traffic, make minor repairs, provide nominal amounts of fuel, push vehicles from the road, radio for help, and clean up minor accidents from the roads. They are not heavy-duty towing trucks.

System Design & Integration

The costs for system design and integration were based on a large system. The costs for the medium and small areas were scaled accordingly to 0.8 for medium and 0.7 for a small system.

Other

Under "Road Communication," costs are listed as per intersection. These costs include codecs, leased lines, video switches, and interconnection of signal.

Electronic Toll Collection Systems

For large metropolitan areas, 15 lanes are assumed per toll plaza. For medium and small areas, 10 and 6 lanes are assumed, respectively. Large areas have 20 toll plazas and medium and small have 10 and 2, respectively. It is assumed that 40 percent of the lanes in the large and medium toll plazas use AVI technologies. The small metropolitan areas are assumed not to use AVI technology.

Electronic Fare Payment Systems

The cost of proximity (smart) cards and related detection/communication equipment is not high, relatively speaking. Implementing a system, however, requires an extensive equipment base, communications infrastructure, and data processing center. These cost figures assume that the electronic fare payment system is installed on an existing transit infrastructure.

Software allows the smart cards to be used as a conventional stored value card, an employee pass, a discount value card (student or handicapped), a bus transfer, a bus farecard, and a parking lot farecard. As the use of the smart cards expands, additional software will be required to allow account reconciliation between different transportation providers accepting the same card, expanded control measures for a larger card population base, and specific operational requirements for both new and existing users.

MODEL DEPLOYMENT ELIGIBILITY

As described below, the US DOT is proposing a limited number of "model deployments" of the core infrastructure needed to support regional traveler information services in metropolitan areas. This proposed initiative is designed to accelerate national deployment of ITS products and services through example -- by supporting "model ITS deployments" in a limited number of metropolitan areas to educate the general public and local decision makers on the benefits of ITS user services, and to assess benefits and costs.

Objective: The objective of this proposed initiative is to provide model deployments of a core metropolitan-area information, communications, and traffic and transit management infrastructure that would support regional traveler information services. (The items with a "Y" in the "model deployment" column of the attached spreadsheet indicate that they are probable elements that would be funded through the model deployment initiative.) In addition to introducing the public to ITS products and services, the sites would serve as "showcases" for key local decision makers across the U.S. and the sites would support tours and seminars focused on the benefits of ITS investments by both the public and private sectors.

Approach: Pending approval of funding, the US DOT plans to issue a solicitation in early fiscal year 1996 to select up to three metropolitan areas for model deployments of an ITS core infrastructure that would support operation and management of roadway and transit resources and the provision of regional traveler information services. The proposed model deployments will focus on the use of currently available technologies and strengthened institutional ties. Sites that offer the greatest potential for demonstrating all aspects of a core transportation management and traveler information system, (including institutional and technological infrastructure) for the least Federal dollars will be considered the most desirable. A 50% match will be required, along with private sector participation in the match.

The US DOT will generally negotiate with the lead public agency (State, city or regional agency, depending on the site) to ensure an up front commitment to providing the needed core infrastructure within the parameters of the National ITS Architecture. Negotiations will ensure that needed institutional arrangements are in place, and that the private sector is involved as an infrastructure provider (e.g., communications), as a franchisee (e.g., for information dissemination), or in another capacity contributing significant resources to the project.

It is the intent of the US DOT that all proposed contracts, project agreements, and institutional arrangements are in place by the conclusion of the National ITS Architecture development in July, 1996 so that design and construction could begin immediately. The goal is for each site to have regional traveler information services, supported by the ITS model deployments, operational by the end of calendar year 1997.

CORE INFRASTRUCTURE MODEL DEPLOYMENT COST EXAMPLE FOR ATLANTA, GEORGIA

Since, no two metropolitan areas are exactly alike, it is impossible to specify an exact number of transportation elements which will be appropriate for every situation. The quantities listed in the attached spreadsheet are best estimates for particular sizes of metropolitan areas. Another issue which complicates estimating the cost for a model deployment of core infrastructure transportation technologies is that certain decisions are made at the state department of transportation level that affect the number and type of transportation technologies that an area chooses to deploy. These decisions may or may not be consistent with the elements listed in the attached cost analysis spreadsheet. Taking the above considerations into account, it was determined that an actual case study which accounts for existing infrastructure and future needs would be beneficial. The Atlanta metropolitan area is used as a case study for example purposes only.

To obtain the status of Atlanta's transportation system, discussions were had with officials in the Atlanta area and the results incorporated into the spreadsheet. The numbers in the "Atlanta Example" column refer to Atlanta's **needs** and do not necessarily reflect that it has or doesn't have the number of elements specified in the "QUAN LARGE" column of the spreadsheet. For example, under incident management equipment, Atlanta is listed as needing 20 incident management vehicles. The spreadsheet indicates that a typical large metropolitan area may have 40 of these vehicles. This does not mean that Atlanta already has 20 vehicles and needs 20 more, but rather that it is **in need of** 20. The legend for the Atlanta example follows:

"0" It **does not necessarily mean** that they have the number specified in the quantity columns, but rather it is felt that their supply of that element is adequate.

"#" This indicates that they could use "#" more of that particular element.

*COST ANALYSIS FOR CORE INFRASTRUCTURE: LARGE, MEDIUM, AND SMALL METRO AREAS

ELEMENTS	QUAN LARGE	QUAN MEDIUM	QUAN SMALL	UNT COST O&M ($K)	UNT COST CAPITAL ($K)	O&M COST LARGE ($K)	CAPITAL COST LARGE ($K)	O&M COST MEDIUM ($K)	CAPITAL COST MEDIUM ($K)	O&M COST SMALL ($K)	CAPITAL COST SMALL ($K)	MODEL DEPLOYMENT Y or N	ATLANTA EXAMPLE ****	O&M COST ($K)	CAPITAL COST ($K)
SURVEILLANCE															
Point Detection (loops)	40,000	25,000	1,500	0.04	0.80	1,600	32,000	1,000	20,000	60	1,200	N	0	0	0
CCTV Cameras	650	450	110	1.00	20.00	650	13,000	450	9,000	110	2,200	N	250	250	5,000
Video Image Proc'g\intx	250	150	0	2.00	40.00	500	10,000	300	6,000	0	0	N	225	450	9,000
Environ'l Sensors\area	100	70	40	0.20	4.00	20	400	14	280	8	160	N	0	0	0
HOV lane control & monitoring equ't\ area	10	8	0	12.50	250.00	125	2,500	100	2,000	0	0	N	0	0	0
SUBTOTAL ($K)						2,895	57,900	1,864	37,280	178	3,560	N		700	14,000
TRAVELER INFORMATION															
Fixed CMS & Contrlrs	100	75	25	10.00	200.00	1,000	20,000	750	15,000	250	5,000	N	86	860	17,200
Fixed HAR & Contrlrs	10	7	2	1.00	20.00	10	200	7	140	2	40	N	25	25	500
Hybrid CMS (arterials)	100	80	0	1.00	20.00	100	2,000	80	1,600	0	0	N	0	0	0
Ramp Meter sys (per interchange)	400	300	0	2.00	40.00	800	16,000	600	12,000	0	0	N	0	0	0
Signal Upgrades	2,500	1,500	50	0.25	5.00	625	12,500	375	7,500	13	250	N	0	0	0
SUBTOTAL ($K)						2,535	50,700	1,812	36,240	265	5,290	N		885	17,700
COMMUNICATION															
Callboxes	1,600	1,200	0	0.50	5.00	800	8,000	600	6,000	0	0	N	0	0	0
Fiber-Optic Cable\mi	400	300	50	12.00	240.00	4,800	96,000	3,600	72,000	600	12,000	N	223	2,676	53,520
Signal Communication per intersection	2,500	1,500	50	0.50	10.00	1,250	25,000	750	15,000	25	500	N	0	0	0
SUBTOTAL ($K)						6,850	129,000	4,950	93,000	625	12,500	N		2,676	53,520
TRANSP'N MGT CTRS															
Computers & Hardware	1	1	1	34.00	680.00	34	680	27	544	24	476	N	0	0	0
Software (various)	1	1	1	11.00	220.00	11	220	11	220	11	220	N	0	0	0
Facilities and Communication	1	1	1	200.00	4,000.00	200	4,000	160	3,200	140	2,800	N	0	0	0
O&M Personnel	36	24	15	50.00	0.00	1,800	0	1,200	0	750	0	N	0	0	0
ADDITIONAL TMCs	5	3	0	2,045.00	4,900.00	10,225	24,500	4,908	11,760	0	0	N	0	0	0
SUBTOTAL ($K)						12,270	29,400	6,306	15,724	925	3,496	N		0	0
TRAVELER INFO CTR															
Computers and Hardware	1	1	1	5.10	102.00	5	102	4	82	4	71	Y	0	0	0
Software (various)	1	1	1	15.00	300.00	15	300	15	300	15	300	Y	0	0	0
Facilities and Communication	1	1	1	200.00	4,000.00	200	4,000	160	3,200	140	2,800	Y	0	0	0
Kiosks	200	150	50	10.00	30.00	2,000	6,000	1,500	4,500	500	1,500	Y	70	700	2,100
O&M Personnel	30	25	10	50.00	0.00	1,500	0	1,250	0	500	0	Y	0	0	0
SUBTOTAL ($K)						3,720	10,402	2,929	8,082	1,159	4,671	Y		700	2,100
TRANSIT MGT CTR															
Computers and Hardware	1	1	1	17.00	340.00	17	340	14	272	12	238	N	0	0	0
Software (various)	1	1	1	4.50	90.00	5	90	5	90	5	90	N	0	0	0
Facilities and Communication	1	1	1	200.00	4,000.00	200	4,000	160	3,200	140	2,800	N	0	0	0
O&M Personnel	3	2	1	50.00	0.00	150	0	100	0	50	0	N	0	0	0
SUBTOTAL ($K)						372	4,430	278	3,562	206	3,128	N		0	0

*MUST USE THE DETAILED ASSUMPTIONS DOCUMENT TO INTERPRET THIS TABLE.

*COST ANALYSIS FOR CORE INFRASTRUCTURE: LARGE, MEDIUM, AND SMALL METRO AREAS

TRANSIT VEHICLE INTERFACES															
Kiosk, cellular radio etc\ per veh	2,000	1,200	100	0.32	6.30	630	12,600	378	7,560	32	630	Y	0	0	0
SUBTOTAL ($K)						630	12,600	378	7,560	32	630	Y		0	0
EMERGENCY MGT CTRS															
Computers & Hardware	1	1	1	17.00	340.00	17	340	14	272	12	238	N	0	0	0
Software (various)	1	1	1	3.00	60.00	3	60	3	60	3	60	N	0	0	0
Facilities and Communication	1	1	1	200.00	4,000.00	200	4,000	160	3,200	140	2,800	N	0	0	0
O&M Personnel	3	2	1	50.00	0.00	150	0	100	0	50	0	N	0	0	0
SUBTOTAL ($K)						370	4,400	277	3,532	205	3,098	N		0	0
EMERGENCY VEHICLE SERVICES															
Cellular radio, Comm service/veh	3,300	2,500	500	0.02	0.30	50	990	38	750	8	150	N	0	0	0
SUBTOTAL ($K)						50	990	38	750	8	150	N		0	0
INCIDENT MGT EQUIPMENT															
Vehicles	40	25	0	2.50	50.00	200	2,000	125	1,250	0	0	N	20	50	1,000
Portable HAR	10	5	3	2.50	50.00	50	500	25	250	15	150	N	0	0	0
Portable CMS	15	10	10	1.50	30.00	45	450	30	300	30	300	N	0	0	0
O&M Personnel	40	30	5	50.00	0.00	2,000	0	1,500	0	250	0	N	0	0	0
SUBTOTAL ($K)						2,295	2,950	1,680	1,800	295	450	N		50	1,000
SYS DESIGN & INTEGRATION															
TMC, TIC, EMC, TRANSIT MC	1	1	1	0.00	5,400.00	0	5,400	0	4,320	0	3,780	Y	0	0	0
SUBTOTAL ($K)						0	5,400	0	4,320	0	3,780	Y		0	0
ELECTRONIC TOLL COLLEC'N SYS															
Manual/AVI (per lane)	30	10	0	147.00	73.00	4,410	2,190	1,470	730	0	0	N	0	0	0
Automatic/AVI (per lane)	15	5	0	48.00	70.00	720	1,050	240	350	0	0	N	0	0	0
Manual/Automatic/AVI (per lane)	15	5	0	116.00	125.00	1,740	1,875	580	625	0	0	N	0	0	0
AVI Dedicated (per lane)	30	10	0	5.00	16.00	150	480	50	160	0	0	N	0	0	0
Express AVI (per lane)	30	10	0	5.00	16.00	150	480	50	160	0	0	N	0	0	0
AVI Plaza Computer equ't	20	10	0	7.00	130.00	140	2,600	70	1,300	0	0	N	0	0	0
SUBTOTAL ($K)						7,310	8,675	2,460	3,325	0	0	N		0	0
ELECTRONIC FARE PAYMENT SYS															
Central Computer System	1	1	0	150.00	3,000.00	150	3,000	150	3,000	0	0	N	0	0	0
Ticket Vending Machines	500	300	0	3.00	60.00	1,500	30,000	900	18,000	0	0	N	0	0	0
Sys Engr, Prog Mgt, Installation	1	1	0	0.00	16,000.00	0	16,000	0	9,600	0	0	N	0	0	0
Training & Documentation	1	1	0	4.00	80.00	4	80	4	80	0	0	N	0	0	0
Bus Farebox	2,000	1,200	0	0.35	7.00	700	14,000	420	8,400	0	0	N	0	0	0
Station Controller	65	35	0	1.00	20.00	65	1,300	35	700	0	0	N	0	0	0
Turnstile	600	400	0	1.38	27.50	825	16,500	550	11,000	0	0	N	0	0	0
Ticket Office Machine & Validator	100	80	0	1.22	24.40	122	2,440	98	1,952	0	0	N	0	0	0
Smart Card	************	1,000,000	0	0.00	0.01	1,000	20,000	500	10,000	0	0	N	0	0	0
SUBTOTAL ($K)						4,366	103,320	2,657	62,732	0	0	N		0	0

*MUST USE THE DETAILED ASSUMPTIONS DOCUMENT TO INTERPRET THIS TABLE.